Strawberry Creek Restoration Environmental Assessment

Redwood National Park
Humboldt County, California
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INTRODUCTION

Strawberry Creek is a perennial tributary of Redwood Creek that flows across the historical Redwood Creek floodplain in the Orick valley in northwestern Humboldt County (figure 1). Strawberry Creek was once known locally as a productive coastal cutthroat trout stream that also supported healthy populations of steelhead trout and coho salmon, both of which are now federally listed as threatened species. The National Park Service (NPS) is proposing to rehabilitate sections of Strawberry Creek in the park to restore stream habitat for threatened fish species, in partnership with local landowners and agencies who are working to rehabilitate sections of the creek downstream of the park.

Strawberry Creek historically flowed through a forested wetland before entering the Redwood Creek estuary. Conversion of the Orick valley to agricultural use began in the 1800s. By 1935 most of the bottomland had been cleared for sheep and dairy ranches. The forests, wetlands, and low gradient channel of Strawberry Creek were cleared, ditched, and drained to convert the palustrine emergent wetlands and Sitka spruce forest to pastureland for grazing. Clearing the native riparian and wetland vegetation, draining the wetlands, ditching and straightening the creek and tributaries, and installing culverts disrupted the hydrology of the stream, altered salmonid habitat, and created conditions favoring invasion of reed canary grass (*Phalaris arundinacea*). Although most of lower Strawberry Creek remains a wetland, its original riparian wetland functions and values have been altered. Reed canary grass chokes the channel which blocks fish passage upstream, decreases water quality by reducing dissolved oxygen, promotes sedimentation, and impedes the conveyance of storm flows.

Proposed restoration activities to improve fish habitat would include controlling reed canary grass that has filled in the stream channel; excavating a channel to re-establish a free-flowing stream and side channels; re-establishing the riparian canopy by planting native trees and shrubs; replacing undersized culverts with culverts that are large enough to accommodate 100-year flow events and that can be negotiated by fish to move into upstream habitat; and removing sediment sources at stream crossings on abandoned logging roads in the headwaters of Strawberry Creek upslope of the stream valley.

The proposed Strawberry Creek stream restoration encompasses about 9,000 feet of lower Strawberry Creek upstream of the former Redwood National Park South Operations Center (SOC) to the confluence with the South Slough of Redwood Creek. The NPS portion of the project area contains about 1,700 linear feet of Strawberry Creek in four segments: an approximately 500-foot-long segment of the creek adjacent to SOC down to and including a culvert under the SOC Road; an approximately 400-foot-long segment of the creek downstream of the SOC Road culvert to the confluence with the

East Fork Tributary; about 800 linear feet of main channel of the creek from the confluence with East Fork Tributary downstream to the park boundary; and restoration of the lower portion of the West Tributary, beginning about 150 feet upstream of the SOC Road and extending downstream of the road, through a field presently overgrown with reed canary grass and with no defined channel to the main stem reach, approximately 200 feet downstream of the SOC Road.

The project provides the opportunity to refine channel restoration approaches and improve the effectiveness of future restoration efforts. Design objectives of the channel restoration within the project area include: (1) creation of open, slow velocity slough channels with side channels; (2) control of invasive grass species through riparian shading; and (3) restoration of areas of seasonal overbank inundation that provide biologically productive areas supporting native aquatic species, including foraging coho salmon.

The Strawberry Creek restoration project on NPS lands analyzed in this environmental assessment is a component of a larger effort to restore lower Strawberry Creek from SOC to the confluence with the South Slough of the Redwood Creek estuary. Restoration efforts are guided by the 2006 Lower Strawberry Creek Restoration Planning Report (RCWG 2006a) and the Lower Strawberry Creek Restoration Planning Report (Love and Associates 2008). The creek flows through multiple ownerships. Each landowner will take the lead to restore their respective reaches as funding or other constraints allow.

Restoration outside of the park is not part of the NPS project analyzed in this document. Restoration actions outside the national park are described as part of the cumulative impacts of the project as reasonably foreseeable future actions, although implementation is not assured. A non-profit organization, Pacific Coast Fish, Wildlife, and Wetlands Restoration Association (PCFWWRA), has been awarded a grant under the California Department of Fish and Wildlife Fisheries Restoration Grant Program (CDFW FRGP) for planning and implementing a portion of this project; other restoration actions downstream have also received grants under this program. Partners undertaking these other projects will be responsible for preparation of environmental analyses and other required compliance documents.

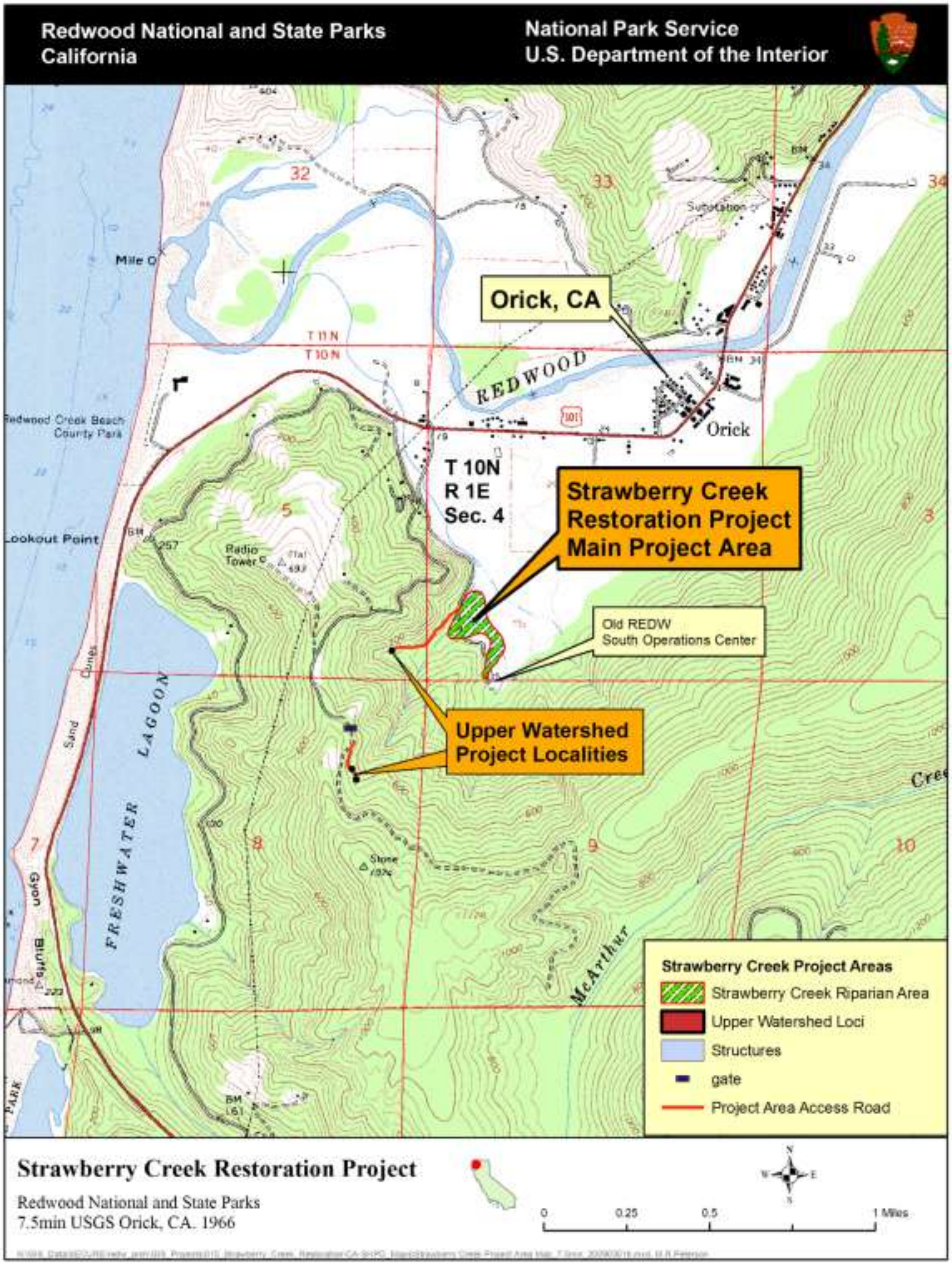

Figure 1. Location of Strawberry Creek Restoration Project in Redwood National Park

PURPOSE AND NEED FOR FEDERAL ACTION

The purpose of the project is restore the structure and hydrologic functions of Strawberry Creek by removing vegetation and excavating a channel to re-establish a free-flowing stream and side channels; re-establishing a riparian corridor with native vegetation to assist in the control of invasive plants in and adjacent to the stream channel; replacing culverts that impede fish passage and alter natural hydrologic and geomorphic processes; and eliminating sources of erosion to reduce sediment delivery into the stream.

This action is needed to enhance populations of threatened fish species through restoring access to designated critical habitat, improving water quality, and improving biological productivity in stream channels to support non-natal rearing of salmonids.

RELEVANT LAWS, POLICIES, AND PLANS

Redwood National Park was established by Congress in 1968 to "preserve significant examples of the coastal redwood … forests and the streams … with which they are associated for purposes of public inspiration, enjoyment, and scientific study." [Public Law 90-245]. Congress expanded Redwood National Park in 1978. The expansion area included about 48,000 ac, most of which had been logged and which included a dense network of roads that had been constructed to provide access to timber harvest areas and to haul logs on trucks to mills. The 1978 legislation expanding Redwood National Park authorized the NPS to develop a program for the rehabilitation of logged and roaded watersheds "to reduce risk of damage to streamside areas and for other purposes" [Public Law 95-250, Section 101(a) (6)]. Since 1978, the NPS has been conducting watershed restoration activities in accordance with the legislation.

NPS Management Policies

It is NPS policy to strive to restore the integrity of park resources that have been damaged or compromised in the past (NPS 2006 1.4.7.2). *Management Policies 2006* allows NPS intervention in natural biological and physical processes to restore natural ecosystem functioning that has been disrupted by past or ongoing human activities (NPS 2006 4.1). The Strawberry Creek restoration project is intended to restore stream functions, especially habitat for anadromous fish now listed as threatened species, within a portion of a wetland that has resulted from past alteration of the creek for agricultural purposes.

Redwood National Park Watershed Restoration

Since 1981, the NPS has undertaken watershed rehabilitation and restoration activities in the Redwood Creek watershed, including the Redwood Creek estuary. These activities were originally described in the *Redwood National Park Watershed Rehabilitation Plan*, approved in March 1981 (NPS 1981 a, b) and the *Management Alternatives for the Redwood Creek Estuary*, approved in September 1983 (NPS 1983 a, b).

The 1999 Redwood National and State Parks *Final General Management Plan/General Plan, Final Environmental Impact Statement/Environmental Impact Report* (RNSP GMP/FEIS) described a program to remove or upgrade abandoned logging roads to reduce the potential for erosion at stream crossings and from unstable road segments in accordance with the 1978 legislation. The proposed action to remove four stream crossings on abandoned logging roads in the upstream portion of Strawberry Creek watershed would be implemented as part of the watershed restoration program described in the GMP. The proposed action to restore a segment of Strawberry Creek as an anadromous fish stream draining into the Redwood Creek estuary is consistent with the direction in the GMP to collaborate with other federal, state, and local agencies, conservation organizations, and affected landowners to restore natural functioning to the estuary. This environmental assessment (EA) is tiered off the 1999 GMP/FEIS.

Floodplains and Wetlands Executive Orders
The NPS carries out its responsibilities to manage floodplains and wetlands in compliance with Executive Orders (EO) 11988 “Floodplain Management” and 11990 “Protection of Wetlands” under procedures described in Director’s Orders (DO) #77-1 Wetland Protection and #77-2 Floodplain Management and their associated implementation manuals.

The purpose of the proposed action is to restore natural floodplain and channel functions and values in a small area. Such actions that are located in floodplains but do not adversely affect floodplain processes and functions and do not involve overnight occupation or present other human health and safety issues may be excepted from the NPS requirement to prepare floodplain statements of findings.

Under Section 4.2.1.h of NPS *Procedural Manual #77-1: Wetland Protection*, NPS actions designed specifically for the purpose of restoring degraded natural wetland, stream, riparian, or other aquatic habitats or ecological processes may be excepted from the requirement to prepare a wetland Statement of Findings. The NPS has determined that the preferred alternative meets the requirements of this exception, including the best management practices and conditions listed in Appendix 2 of the manual. Therefore, Statements of Findings for effects to Floodplains (FSOF) and Wetlands (WSOF) will not be prepared for this project.

STRAWBERRY CREEK PROJECT PLANNING AND DESIGN

REDWOOD CREEK WATERSHED GROUP

The Redwood Creek Watershed Group (RCWG) is a collaborate partnership of federal, state, and local agencies, organizations, and landowners working to improve watershed conditions, preserve current land uses, and provide economic opportunity for the Orick community. The RCWG prepared the *Redwood Creek Integrated Watershed Strategy*

(RCWG 2006a) to outline goals and management strategies to improve and protect water quality, water supply, and aquatic and riparian habitat throughout the Redwood Creek watershed, including the estuary and coastal areas. Restoration of Strawberry Creek is identified as a specific project in the strategy. The watershed-wide *Aquatic and Riparian Habitat Restoration Strategy for Strawberry Creek near Orick, Humboldt County* (RCWG 2006b) was prepared as a comprehensive restoration strategy to address the entire Strawberry Creek watershed.

Site Evaluations and Designs— In 2006, PCFWWRA received grant funding to develop detailed recommendations for improving fish passage and estuarine and freshwater habitat to guide restoration efforts on Strawberry Creek. Funding was provided by U.S. Fish and Wildlife Service Coastal Program and Resources Legacy Fund Foundation Preserving Wild California (Love and Associates 2008). Design commenced with topographic surveys and hydrologic analyses in December 2006. The study area extended from upstream of SOC facility downstream to the South Slough of Redwood Creek. The study included topographic surveys and water surface elevation profiles. As part of the study, staff from Redwood National Park, the U.S. Fish and Wildlife Service (USFWS), PCFWWRA, and consulting hydrologists, geologists, and design engineers visited the Strawberry Creek project area with the owner of land downstream adjacent to the national park to gain historical perspective and refine project objectives.

Water surface profiles elevations were first surveyed throughout most of the project area including NPS and downstream reaches during winter base flow conditions in 2006-2007, when reed canary grass was present throughout most of the active channel. In the summer and fall in 2007, reed canary grass was cleared from the active channel from the Humboldt County Waste Transfer Station to a duck blind on the private property immediately downstream of the project area to facilitate additional survey work and allow riparian planting to occur on downstream private land reaches. The channel clearing caused water levels to drop noticeably throughout the lower 3,400-foot section of channel. Subsequently, the water surface at the Hiltons Road and the Highway 101 culvert was resurveyed during base flow conditions in November 2007. Model results show that removing the reed canary grass allow the two-year recurrence interval flow to be conveyed within the channel banks throughout the stream reaches downstream of the project area. Observations indicate removal of the reed canary grass from the channel lowers the water surface by as much as three feet during a winter base flow of approximately of five cubic feet per second (cfs).

Hydraulic modeling shows that removal of four high points in the channel that cause water to back up and flood upstream areas may lower two-year water levels as far upstream as the SOC Tributary confluence in the project area.

The design of the project is based on an evaluation of these and other observations, surveys, and measurements of topography, hydrology, geomorphology; biological characteristics of the project area; hydraulic modeling; fish passage assessment modeling; evaluation of a reference reach of stream above SOC; historical documents; and aerial photographs from 1936, 1948, 1962, 1968, as well as more recent photographs (Love and Associates 2008).

HABITAT FOR ANADROMOUS SALMONIDS IN STRAWBERRY CREEK

Two species of anadromous salmonids that have been found in Strawberry Creek downstream of the NPS project area are listed as threatened under the federal Endangered Species Act, Southern Oregon/Northern California Coast (SONCC) coho salmon and Northern California steelhead. Coho salmon are also listed as threatened under the California Endangered Species Act. A third anadromous salmonid, coastal cutthroat trout, is also found in Strawberry Creek. Chinook salmon are not known to occur in Strawberry Creek but do occur in Redwood Creek.

Anadromous salmonids spend most of their adult lives in the ocean and migrate from the ocean to spawn in the same freshwater streams in which they were born (natal streams). These fish require clean spawning gravels that are free of fine sediment to allow the eggs and early life stages to obtain sufficient oxygen to survive.

Recent studies have found that low gradient streams that are tributaries to an estuary provide rearing habitat for juvenile coho salmon and other salmonids (Koski 2009). Some juvenile coho salmon are “nomads” that are hatched in other streams and migrate to these non-natal streams to rear (Koski 2009). The rearing habitat in low gradient streams near estuaries, such as Strawberry Creek which enters the Redwood Creek estuary, commonly produce coho smolts that are relatively large, which substantially increases their chance of survival. The low gradient streams close to the estuary and the estuarine habitat have largely disappeared from lower Redwood Creek due to land use activities and the development of flood control levees.

Under current degraded conditions, potentially suitable habitat for coho and steelhead currently does not occur within the NPS portion of the project area of Strawberry Creek and its tributaries.

RESTORATION OBJECTIVES FOR STRAWBERRY CREEK

Six implementation objectives have been established for Strawberry Creek restoration (Love, Shea, and Llanos 2008, Love and Shea 2010, 2011, 2012).

1. Remove and control invasive reed canary grass from portions of the stream channel, wetland, and floodplain.
2. Restore portions of the stream channel to re-establish natural geomorphic processes.
3. Revegetate the riparian corridor with native species.
4. Fence the new plantings along the riparian corridor to prevent damage by elk browsing and associated streambank erosion.

5. Replace undersized stream crossings that impede fish passage and alter natural geomorphic processes.
6. Eliminate critical erosion sites with the potential for sediment delivery into the stream and wetland from the upper watershed.

ALTERNATIVES, INCLUDING THE PROPOSED ACTION

This environmental assessment analyzes three alternatives: a no-action alternative as required under the NPS guidelines for implementing the National Environmental Policy Act (NEPA) and two action alternatives for restoration of Strawberry Creek within Redwood National Park, Strawberry Creek restoration (Alternative 2, the proposed action) and a more extensive restoration alternative (Alternative 3). Graphics illustrating the no-action alternative (existing conditions) and the action alternatives appear in Appendix A. Table 1 lists major construction elements for the action alternatives.

The restoration design alternatives for the Strawberry Creek channel upstream of the wetland and the West Tributary upstream of the SOC Road are based in part on characteristics of a selected reference channel reach located approximately 1,000 feet upstream of the project area on the main stem of Strawberry Creek. The surveyed reference reach is a stable channel 120 feet in length and characterized by wood-forced steps and pools, low banks, and a broad floodplain with a mature alder-dominated riparian forest.

ALTERNATIVE 1: NO ACTION

The no-action alternative is required under NPS guidelines for compliance with the National Environmental Policy Act (NEPA) and is used to compare existing conditions with the proposed action. A no-action alternative means either a continuation of existing management practices or “no project.” In this case, the no-action alternative is the current management action, which includes maintenance of the SOC Road and the two culverts (West Tributary and SOC).

Under the no-action alternative, reed canary grass and other vegetation would not be removed to clear stream channels within the wetland. Creek channels would not be realigned. Existing culverts under the SOC Road would remain. The upper watershed stream crossings on abandoned logging roads would remain in their present configuration and condition.

Under this alternative, the NPS would perform minimal maintenance of the existing culverts by periodically removing debris that accumulates at the culvert inlets. Culverts would be replaced when they wear out or when they no longer function to convey water beneath the SOC Road. The undefined channels of Strawberry Creek and the West Tributary would remain in their present condition. The headwater stream crossings would not be excavated or receive any routine maintenance because of their location on unmaintained abandoned logging roads.

ACTION ALTERNATIVES

Actions for restoration of Strawberry Creek that would occur under both action alternatives include the following:

- reed canary grass and other vegetation would be removed from stream channels and piled at the SOC maintenance storage yard to decompose naturally.
- stream channels that allow fish passage would be re-established, realigned, and/or created.
- wood and rock structures would be constructed and/or installed in stream channels to support channel function and stability.
- earthen material excavated from on-site supplemented with additional off-site material as needed would be used to create mounds adjacent to stream channel and planted with native trees and shrubs to create a riparian zone.
- planted areas would be fenced to prevent elk and beaver from damaging new plantings.
- culvert[s] would be replaced with “fish-friendly” culverts sized for 100-year recurrence interval flows and that allow fish passage.
- utility lines would be temporarily relocated.
- four stream crossings in the upper watershed would be removed and restored as closely as possible to the original landform.

The project alternatives have the potential to alter two types of elements within the project area: constructed elements such as roads, culverts, and utilities; and naturally occurring features such as soils, hillslopes, the stream and tributaries, and vegetation. Figure A-1 shows existing conditions with the exception of the upslope stream crossings.

Existing constructed elements include:

1. a log stringer bridge on creek upstream of the former offices at SOC;
2. a 24-inch-diameter corrugated metal pipe (CMP) culvert underneath SOC Road near former SOC buildings;
3. an 18-inch CMP culvert underneath the SOC Road on the West Tributary;
4. utility lines that serve park administrative facilities; and
5. stream crossings on abandoned logging roads on the hillslopes above Strawberry Creek.

Natural features include:

1. the upper reach of Strawberry Creek that drains the hillslope behind the former administrative buildings downstream to the inlet of the SOC Road culvert;
2. Strawberry Creek from the SOC Road culvert to the confluence with the East Tributary;
3. Strawberry Creek main channel downstream from confluence with East Tributary to park boundary;
4. West Tributary upstream and downstream of SOC Road to the confluence with the main Strawberry Creek channel; and

5. the wetland which includes original stream channels now buried in sediment or covered with invasive grasses.

Restoration actions differ between the two action alternatives for the following constructed elements or natural features:

1. SOC Tributary upstream of SOC Road, including:
   - SOC culvert under the SOC Road;
   - SOC Tributary from the SOC Road culvert upstream to the log stringer bridge, none of which is in the wetland complex; and
   - the log stringer bridge behind the former administrative buildings at SOC.

2. Strawberry Creek channel, including:
   - SOC Tributary from the SOC Road culvert downstream to the confluence with the East Tributary, the downstream end of which is located within the wetlands classified as Palustrine Emergent under the Cowardin classification; and
   - Main Strawberry Creek channel from confluence with East Tributary to the park boundary, all of which is located in the Palustrine Emergent wetland.

3. West Tributary, including:
   - West Tributary culvert under the SOC Road;
   - West Tributary upstream of the SOC Road, which includes wetlands classified as Palustrine Forested under the Cowardin system; and
   - West Tributary downstream of SOC Road to confluence with Strawberry Creek, some of which is within the wetland.

4. Elements to be constructed or placed in or adjacent to the restored stream channels including:
   - planting mounds;
   - log steps and weirs;
   - rock and boulder steps and weirs;
   - wood habitat structures; and
   - anchoring systems for steps and weirs

TABLE 1. COMPARISON OF STREAM RESTORATION ACTIONS UNDER ACTION ALTERNATIVES

[Lengths (linear feet, lf) and volumes (cubic yards, cu yd) of natural features such as stream channels, and excavation areas in acres (ac) and square feet (sq ft) are estimates or approximate measurements calculated from best available information derived from engineering drawings and computer mapping systems.]

Item	Alt 2 (proposed action)	Alt 3 (more extensive restoration)
SOC Tributary upstream of SOC Road		
• Log stringer bridge	Not treated	Removed
• Stream channel	No channel restored	500 feet restored
• 24” Culvert	Not replaced	Replaced with CMPA 11.4’ ×7.3’, 45’ long
Strawberry Creek Channel (restored length)		
• SOC Tributary from culvert to East 282 Fork Tributary confluence	404 lf	404 lf
• Main Channel from East Fork tributary to park boundary	820 lf	820 lf
West Tributary Channel		
• West Tributary (WT) culvert	Replaced with CMPA 8.6’ × 5.9’, 45’ long	Replaced with CMPA 9.8’ × 6.6’, 46’ long
• West Tributary channel upstream of road	186 lf restored and realigned	222 lf restored along present alignment
• West Tributary channel downstream of road	200 lf restored with more easterly orientation	220 lf restored with northerly orientation
Flow-Through and Dead End Channels (length created)		
• Flow-through channel parallel to main channel	255 lf	260 lf
• Dead-end channels	245 lf	300 lf
Constructed Elements		
• Planting mounds	0.84 ac (36,754 sq ft)	0.74 ac (32,203 sq ft)
• Log steps and weirs	5 in main channel; 7 in WT	38 in main channel; 10 in WT
• Rock and boulder steps and weirs	20 in WT and WT culvert	15 in main channel; 14 in WT and WT culvert
• Wood habitat structures	7 in main channel	12 in main channel; 2 in WT
• Nurse logs adjacent to main channel	10	10
• Anchoring systems	Logs bolted together; piles driven into banks to anchor to ground	Logs bolted together; bolted to rebar to anchor into ground
Non-wetland Area Excavated	0.68 ac (29,484.95 sq ft)	0.8 ac (35,185 sq ft)
Wetland Area Grubbed or Excavated	2.2 ac (95,943.47 sq ft)	3.1 ac (134,717 sq ft).
Wetland Vegetation Grubbing Volume	7,130 cu yd	5,000 cu yd
Channel and Culvert Excavation Volume	1,064 cu yd	5,470 cu yd
Limits of Disturbance: Stream Restoration	5.6 ac (243,451.93 sq ft)	6.5 ac (281,919 sq ft)

OVERVIEW OF ALTERNATIVES FOR STRAWBERRY CREEK, WEST TRIBUTARY, AND CHANNEL RESTORATION

Limits of Disturbance

Under the proposed action (Alternative 2), the limits of disturbance needed for equipment access, stockpile areas, grubbing, and excavating is estimated to be about 5.6 ac (figures A-2, A-3, A-4). Under Alternative 3, the limits of disturbance needed for equipment access, stockpile areas, grubbing, and excavating is estimated to be about 6.5 ac (figures A-5, A-6, A-7, A-8).

Restoration Actions Common to Both Action Alternatives

Two temporary access roads would be constructed, one approximately 100 feet in length for heavy equipment access from the SOC Road into the wetland complex (figure A-2) and a second needed for replacement of the SOC Road culvert over the West Tributary approximately 180 in length and 35 feet wide (figure A-3). The roads would be removed at the completion of the project and incorporated into the restoration area.

Vegetation would be excavated from Strawberry Creek and West Tributary to create channels. Channels would be realigned from their original location under both alternatives.

The main stream channels (Strawberry Creek and West Tributary) within the wetland would have a different shape than the dead-end and flow-through channels within the Palustrine Emergent wetland. Main channels are designed as a trapezoid with a wide bottom and steep side slopes (figures A-9, A-10) because this shape has been found to inhibit the recolonization of reed canary grass within a channel in similar restoration projects (Love and Associates 2006).

Flow-through and dead-end side channels would be constructed in wetland areas adjacent to restored main channels. The side channels would be five feet wide with nearly vertical three-foot-high banks with the bottom set at the elevation of the Strawberry Creek slough channel (figure A-10).

Engineered wood structures would be installed in restored channels to create discrete drops to control the channel bed elevation, create scour pools that dissipate the flow energy, and provide fish habitat (figures A-11, A-12, A-13, A-14, A-15).

Under both action alternatives, 385 linear feet of existing SOC Tributary upstream of the wetlands (from the SOC Road culvert downstream to the confluence with the East Tributary) would be excavated. The restored channel would be 404 feet long under both alternatives.

The SOC Tributary channel vertical profile was designed to move the depositional reach downstream of the culvert crossing, and establish the channel elevation low enough to pass under the SOC Road with minimal change to the road profile. The channel slope gradually decreases from upstream to downstream before entering the extremely low slope of the main channel to eliminate the abrupt discontinuity in the sediment transport reach.

Under both action alternatives, the channel downstream of the culvert (SOC Tributary reach to confluence with East Tributary) would be moved away from the toe of the west hillslope and realigned between the hillslope and the underground electrical line, following the slope of the existing ground. The channel would be lowered vertically and realigned horizontally from a straightened, ditch-like channel to a naturally functioning sinuous form. The new channel alignment would follow the slope of the existing ground and mimic the meander geometry of the upstream reference reach, with low sinuosity and gentle meander bends. The realigned main channel from the confluence with the East Tributary to the park boundary would be 820 feet in length under both alternatives.

The West Tributary channel restoration begins about 150 feet upstream of the culvert crossing under the SOC Road at the confluence of two smaller channels. Restoration continues downstream with the replacement of the SOC Road culvert and construction of a new channel for another 220 feet to the confluence of the main channel of Strawberry Creek. Under both alternatives, the West Tributary upstream of the SOC Road culvert would be restored as a step-pool channel, with log steps and log weirs, separated by scour pools, glides, and riffles.

ALTERNATIVE 2 (PROPOSED ACTION): STREAM CHANNEL RESTORATION

Under the proposed action (Alternative 2), the Strawberry Creek realignment would begin at the outlet of the SOC Road culvert and extend downstream to the park boundary for a total restored length of 1,224 linear feet (figures A-2, A-3). The new channel would follow a sinuous alignment along the west side of a berm to meet the existing Strawberry Creek channel about 100 feet upstream of the park boundary. The restored West Tributary channel would be 386 feet long, including segments upstream and downstream of SOC Road (figure A-4).

Within the wetland area, a 255-foot-long flow-through side channel would be parallel to the main channel of Strawberry Creek, diverging from Strawberry Creek near the upstream area of the wetland and connecting with the new West Tributary channel (figure A-3). Several dead-end side channels, totaling approximately 245 feet in length, would connect to the flow-through side channel and to Strawberry Creek and the West Tributary channels (figures A-2, A-3).

ALTERNATIVE 3: MORE EXTENSIVE STREAM CHANNEL RESTORATION

Under the more extensive restoration alternative (Alternative 3), the Strawberry Creek realignment would begin approximately 30 feet upstream of an existing log stringer bridge behind remaining structures at SOC and extend downstream to the park boundary for a total restored length of 1,712 linear feet (figures A-5, A-6, A-7).

Under Alternative 3 only, about 520 feet of the Strawberry Creek upstream of the SOC Road culvert would be realigned and reshaped (figure A-5). The log stringer bridge would be removed.

Under Alternative 3, about 442 feet of channel along the West Tributary of Strawberry Creek would be realigned and restored, including 222 linear feet of the West Tributary upstream of the SOC Road and 220 linear feet of the West Tributary from the SOC Road to the confluence with the main channel (figure A-8). The realigned channel upstream of the SOC Road would be constructed within an open area among large alders and spruce trees to minimize root damage to trees.

Within the wetland areas, a 260-foot-long flow-through side channel would be constructed parallel to the main channel of Strawberry Creek, diverging from Strawberry Creek near the upstream area of the wetland and connecting with the new West Tributary channel (figure A-7). Several dead-end side channels, totaling approximately 300 feet in length, would connect to the flow-through side channel and to Strawberry Creek and the West Tributary channels (figures A-6, A-7).

ALTERNATIVES FOR INSTREAM STRUCTURES IN RESTORED CHANNELS

Under both action alternatives, structures would be placed in the new channels of Strawberry Creek and upstream of the new SOC Road culvert in the West Tributary to control channel bed elevation, create scour pools to dissipate flow energy, and to provide fish habitat. The two alternatives differ in the number, types, location, and anchoring of structures.

Pools, glides, and riffles would be constructed between structures. Structures would be created from both logs and rocks/boulders. Logs would be a minimum of 12 feet in length. Pieces of large wood would be installed along the stream channel to create fish habitat complexity and cover (figure A-14). Large wood would consist of a mix of logs obtained from park stockpile areas. If there is insufficient wood available from in-park sources, wood would be purchased from commercial sources in the area.

Structures to be installed under the proposed action **(**Alternative 2) include:

- 5 log steps in main channel;
- no boulders or rock steps or weirs in the main channel;
- 7 log steps and weirs in the West Tributary;
- 20 rock and boulder steps and weirs in the West Tributary and West Tributary culvert;
- 7 log habitat structures in the main channel; and
- 10 nurse logs adjacent to the main channel.

Under Alternative 2, logs would be bolted together using threaded rebar, with piles driven into banks to anchor structures to ground.

Structures to be installed under more extensive restoration alternative **(**Alternative 3) include:

- 22 log steps in the main channel;
- 16 log weirs in the main channel;
- 4 log steps in the West Tributary;
- 6 log weirs in the West Tributary;
- 15 rock and boulder steps and weirs in main channel;
- 14 rock and boulder steps and weirs in the West Tributary and West Tributary culvert;
- 12 log habitat structures in the main channel;
- 2 log habitat structures in the West Tributary; and
- 10 nurse logs adjacent to the main channel.

Under Alternative 3, logs would be bolted together, and bolted to rebar staked into the ground to anchor structures.

Under both alternatives, rock and boulder steps would be installed inside the West Tributary culvert to provide a natural streambed substrate.

Under both action alternatives, two different types of structures—log steps and log weirs—would be placed to create discrete drops that control the channel bed elevation and create scour pools that dissipate the flow energy.

Using two types of structures would create variability in drop heights, pool lengths, channel cross section, and overall appearance.

Under the proposed action (Alternative 2), both log steps and log weirs would be constructed in the West Tributary. In Alternative 2, log steps but not weirs would be constructed in the Strawberry Creek channel due to its gentler slope.

Under Alternative 3, log steps and log weirs would be constructed in both West Tributary and Strawberry Creek channels.

Steps and weirs were designed based on observations of wood features within the upstream reference reach and in other small streams with large wood features controlling the profile. Although some drops over wood structures in the reference reach were greater than two feet, step heights were limited to a maximum of one foot to facilitate fish passage and manage risk associated with pool scour and undermining of log structures.

Log Steps— Log steps consist of a 2.5- to 3.0-foot-diameter step log spanning the channel at a 60 degree angle to the flow, with the orientation alternating from step to step (figure A-11). The step log would be pitched, with the high side of the log placed at bankfull elevation and the low side of the log placed 1.5 feet lower. [Bankfull flows are those with a return period between 1.2 and 1.5 years, and serve as the dominant "channel forming" flow, which shapes the active channel of a stream system (Leopold et al. 1964.)] The high side of the log creates a sill across the narrow floodplain surface and is keyed into the existing ground to prevent erosion around the ends of the log. A footer log would be installed to a minimum depth of 5 feet below the crest of the log step, with the bottom of the footer log below the estimated pool scour depth (Flosi et al. 2009). A 2-foot-minimum-diameter training log would be installed along the streambank on the low side of the step log to guide the approaching flow away from the stream bank to provide bank protection and focus the plunging flow over the step towards the center of the channel.

Log Weirs— At-grade log weirs would be constructed within the channel reaches where sediment is expected to deposit or where the channel is expected to be backwatered by the water surface of the wetland. Log weirs are designed to maintain channel stability if an upstream log structure fails, with a shorter drop between structures to minimize pool scour depth and reduce the potential for undermining of the structure. No pools would be constructed downstream of these weirs.

Log weirs consist of a 2.5-to-3.0-foot diameter weir log spanning the channel at an angle nearly perpendicular to flow (figure A-12). A large footer log would be installed to a minimum depth of five feet below the crest of the log step, below the computed pool scour elevation (Flosi et al. 2009). Log weirs are keyed deeper into the channel bed than the log steps, to provide an additional safeguard against undermining and cascading failures of log structures. Two-foot-diameter training logs would be installed along both streambanks to guide flows towards the center of the channel and provide bank protection.

In channel reaches with overall slopes of 3% and greater, a large flat-sloped pool would separate each log step and log weir to dissipate energy created by the plunging flow. The downstream end of each pool would be filled with river-run gravel salvaged from Redwood Creek flood control levee channel maintenance project (within-in levee gravel excavated by Humboldt County to maintain capacity for flood control) or purchased from commercial gravel operations. The gravel would form a glide feature to provide habitat for invertebrates and spawning habitat for salmonids. The Redwood Creek materials are slightly larger than the gradation of the channel bed material found in the Strawberry Creek reference reach. This larger material would be less mobile than the native bed material to ensure stability until the newly constructed channel adjusts. The top layer of the installed Redwood Creek material would eventually be transported downstream and replaced with native material, depending on volume, duration, and frequency of flow events.

Log Structure Anchoring— To counteract buoyancy of the wood and reduce the risk of logs moving during high flow events, the logs would be anchored together using threaded rebar and anchored into the ground using wood piles driven into streambanks (figure A-12).

Under Alternative 2 (proposed action), two log piles with minimum 1.5-foot diameter logs, would be driven into both banks to anchor each structure to the ground. Log piles would extend a minimum of 5 feet below the limit of excavation.

Under Alternative 3, log piles driven into the banks with a minimum depth of 10 feet would be installed on one or both sides of the log structures, as necessary (figure A-13). Log piles would be driven a minimum of two feet below the predicted scour pool depth. The step log and weir log associated each structure type would also be bolted to the log pile using 1-inch rebar.

Log Habitat Structures and Nurse Logs— Under both alternatives, 10 nurse logs would be placed adjacent to the main channel and log habitat structures would be installed in the main channel and the West Tributary. The number of habitat structures differs between action alternatives as shown above.

Nurse logs would be placed adjacent to the stream channel. Nurse logs would be a 48-inch minimum diameter, 10 feet in length, with up to 10 holes drilled into the log to plant Sitka spruce seedlings. Seedling roots would be covered with soil to promote growth.

Each habitat structure would have two parallel deadman logs a minimum of 30 feet in length driven at least 20 feet into the stream bank, with a third log (cross log) bolted across the ends of the deadman logs (figure A-14).

ALTERNATIVES FOR CULVERT REPLACEMENT

Culvert Design— For both action alternatives, culverts were designed using the Stream Simulation Approach (Flosi et al. 1998, 2003, 2004, 2009, 2010; NMFS 2001; USDA 2008) based on the reference reach of stream upstream of the culvert.

Culverts would be embedded below finished channel grade to allow construction of a natural channel substrate within the culvert with step-pool morphology to provide suitable passage for fish and other aquatic organisms.

The channel bed in the culvert would be constructed with a similar slope and bed morphology as the adjacent stream channel. Boulder steps would be installed within the new culverts to control the channel profile and facilitate fish passage. Steps were designed based on similar features found throughout the reference channel upstream. River-run gravel from flood control levee maintenance would be placed as the substrate of the new stream channel. The pools below each boulder step would be allowed to self-form.

Given the steep slope and step-pool morphology of the stream simulation channel, and because steps within the natural channel are formed by wood rather than boulders, larger boulder steps were designed to remain stable at the 100-year design flow. Larger-size fractions of the stream simulation bed material would be used to construct the boulder steps within the culvert and key elements of the rock chute. Smaller material would be used to construct the streambed between each boulder step. For additional stability, a 1.5-foot-tall steel bed retention sill would be welded to the culvert bottom in the middle of the culvert and used to buttress one of the boulder steps.

SOC Tributary Culvert— Strawberry Creek crosses under the SOC Road through a 24-inch-diameter CMP culvert, although the inlet, barrel, and outlet are filled nearly to capacity with sediment.

Under the proposed action (Alternative 2), the existing 24-inch CMP culvert would remain (figure A-1).

Under the more extensive restoration alternative (Alternative 3), 520 feet of Strawberry Creek upstream of the SOC Road culvert would be realigned and restored. The elevation of the realigned channel would be more than two feet lower than the existing culvert elevation at the SOC Road crossing, allowing for a larger culvert to be installed at a steeper slope to improve sediment routing and culvert capacity. If needed to maintain 18 inches of cover over the new SOC Road culvert, the road would be raised up to six inches along a 20-foot length. The existing 24-inch CMP culvert would be removed and replaced with an embedded CMP arch culvert (CMPA) 11.4’×7.3’, 45 feet in length (figure A-5).

West Tributary Culvert— Under both alternatives, the 18-inch diameter CMP on the West Tributary would be removed and replaced with a culvert sized to accommodate a 100-year flow event and designed to allow all life stages of fish to move freely through the culvert.

Under Alternative 2 (proposed action), the new West Tributary culvert would be a 103” × 71” CMPA 45 feet long (figure A-4).

Under Alternative 3, the new West Tributary culvert would be a 117”×79” CMPA 46 feet long (figure A-8). Upstream of the West Tributary culvert, a chute or riffle would be constructed within the bankfull channel, with similar dimensions and channel features as the channel bed within the culvert.

ALTERNATIVES FOR VEGETATION MANAGEMENT AND RIPARIAN PLANTING

Both action alternatives include excavating and grubbing in the wetlands to remove invasive grasses and create channels; excavating and grubbing in non-wetland areas to create channels and replace culverts; replanting native vegetation to create riparian zones to shade the new stream channel to prevent reinvasion of reed canary grass; creating mounds which would be planted to simulate existing hummocks; installation of fencing to exclude elk that would browse on the young trees; and maintenance of the channel through removal of reed canary grass until the trees are large enough to shade out the grass.

Streamside riparian areas would be excavated with heavy equipment to remove the reed canary grass and its roots. Excavated material would be hauled to a storage site in the park and composted.

Under the proposed action (Alternative 2), vegetation would be grubbed from approximately 2.2 ac of wetland for channel realignment and mound construction and 0.68 ac of non-wetland for channel realignment.

Under Alternative 3, vegetation would be grubbed from approximately 3.1 ac for channel realignment and mound construction and 0.8 ac in non-wetland areas for channel realignment.

Planting mounds— Under both action alternatives, riparian zones along the stream channel would be created by mounding soil adjacent to the excavated stream channel and planting the constructed mounds (figures A-16, A-17, A-18). Planting mounds would be created using excavated material from the channel restoration portion of the project; from one of the upslope stream crossings; from river-run gravel salvaged from within the Redwood Creek flood control levees if available; and purchased from commercial sources outside the park if other quantities are insufficient or do not meet specifications. The excavated material would be placed on a base created with the imported material; no grubbed material that contains roots of invasive plants would be used to create the mounds. Borrow would consist of natural sand, gravel, or soil material with no individual fragments larger than 3 inches in diameter, no manmade materials, and a minimum of organic material (Caltrans 2006). The planting mounds would create dry ground surfaces above the seasonally high water level where trees can be planted at elevations suitable for each species tolerance to degrees of flooding.

Planting areas include mound plantings, 25-foot-wide riparian zones, and willow staking along the restored channels where no mounds are constructed (figure A-16). A riparian buffer at least 25-foot-wide of densely planted two-year-old Sitka spruce and red alder would be created along the stream channel in higher elevation areas. Within the buffer, willow clumps and stakes would be transplanted along the bankfull elevation of the channel to provide bank stability.

The native species for planting include coniferous trees that grow rapidly and create dense shade year-round, combined with native deciduous trees and shrubs that provide forage, are characterized by rapid growth, and often form thickets that create dense shade year round. The planting scheme would be two-year-old bare-root stock Sitka spruce and alder, nursery-grown from seed. Willow cuttings would be collected from on site or from private land from another location in the Orick valley. Sedges *(Carex obnupta)* would be salvaged from the work area.

Trees would be planted at two foot intervals. Willow stakes would be planted at one foot intervals. A heavy planting scheme would produce a dense canopy zone to shade out and control the reed canary grass to prevent re-invasion of the Strawberry Creek channel. Planting would occur in the late fall after the beginning of the rainy season to provide sufficient time for plantings to take root prior to increasing light in spring. The site would be monitored for at least three years and replanted where necessary to maintain the shaded canopy.

Spruce would be planted on the mounds at 23 feet elevation (all elevations are mean feet above sea level) and above; spruce and alder between 22 and 23 feet; alder between 20.5 and 22 feet; and willow stakes intermixed with sedges from the base of the mounds at 17 feet up to 20.5 feet.

The shape of the planting mounds and the total area planted differs between the two action alternatives. Some of the plantings extend beyond the mound area.

Under the proposed action (Alternative 2), the planting mounds would be created using approximately 7,400 cu yd of material placed next to excavated channel. The mounds would cover approximately 0.84 ac, and planted with spruce at the upper elevations; a mix of alder and spruce at the middle elevations; and willow and sedges at the lowest elevations.

Under Alternative 3, the planting mounds would be created using approximately 5,000 cu yd of fill placed adjacent to the excavated channel and would cover approximately 0.74 ac (figure A-18). Spruce and alder would be planted at the upper elevations, with willow and sedges at the lower elevations.

ACTIONS COMMON TO ALTERNATIVES 2 AND 3

Actions common to Alternative 2 (proposed action) and Alternative 3 (more extensive restoration) include relocation of two utility lines, installation of elk exclusion fencing, and removal of unstable stream crossings on abandoned logging road upstream of the wetland complex.

Utility Relocation— A 6-inch diameter waterline and a telephone line under the SOC Road would be temporarily relocated during installation of the West Tributary culvert. The waterline would be permanently relocated and buried a minimum of 18 inches below finished grade with a minimum one foot of separation between the top of the culvert and the waterline.

Elk Exclusion Fencing— High tensile, six-strand electric fence similar to elk fencing along the park boundary downstream of the project area would be installed around the riparian planting area to exclude elk until the trees are large enough to withstand elk browsing.

Stream Crossing Removal— Under both action alternatives, four intermittent stream crossing sites on abandoned logging roads in the upper watershed would be excavated to remove unstable road fill that could erode and enter the restored stream channels downstream. These sites occur on roads that are, or originally were, about 25 feet wide. The channels are about 14%–45% grade. Crossings are estimated to have been built in the late 1950s to early 1960s and are generally composed of a mix of wood debris and earthen fill. One contains a 6-inch-diameter culvert.

The crossings would be excavated using techniques similar to other watershed restoration projects in the park and would be reshaped to resemble the original contours. The four crossings range from about 150 cu yd to about 800 cu yd each, for a total excavation volume of about 1,600 cu yd. The excavated channels would range from 75 to 140 feet in length and 3–7 feet in width. Excavation at one site is estimated to be about 23 feet in depth; the other three sites are shallower. Berries, shrubs, and other vegetation would be removed, temporarily stockpiled nearby, and spread as mulch on bare soils after excavation to reduce erosion until vegetation regrows. Ground disturbance to remove vegetation and excavate stream crossings is estimated to affect 6,000 sq ft at each of two sites and 3,600 sq ft at each of two other sites, for a total of 19,200 sq ft (0.44 ac) of ground disturbance.

Excavated soil from all four crossings would be either hauled to a storage area at the administrative site and temporarily stockpiled until it can be incorporated into planting mounds or would be placed in a stable location on road benches adjacent to the crossing excavation site. About 1,000 cu yd of excavated material from the crossing closest to the stream restoration area is estimated to be suitable for mound construction.

MITIGATION MEASURES FOR INSTREAM WORK COMMON TO ACTION ALTERNATIVES

Mitigation for Instream Work— Under both action alternatives, mitigation measures required under CDFW FRGP to protect water quality, stream habitat and fish, including erosion control measures, would be implemented (Flosi et al. 1998, 2003, 2004, 2006, 2009; NMFS 2001a, 2001b.) These include grubbing and earth moving adjacent to active stream channels only at low streamflow periods; dewatering procedures for stream channels; fish screens; and fish relocation if needed. Mitigation measures to reduce potential adverse effects on air quality, wildlife, and cultural resources are described in the environmental consequences section under their respective entries. A complete list of required mitigation measures to minimize adverse effects on listed fish species from projects funded under the CDFW 2012 Fisheries Restoration Grant Program is found in the CDFG *California Salmonid Stream Habitat Restoration Manual, Third Edition* (Flosi et al. 1998) and Fourth Edition (Flosi et al. 2010).

Strawberry Creek and the West Tributary are perennial streams. Instream work would occur during the dry season in summer and fall, when stream flows are lowest.

The CDFW requires that all instream work funded under the FRGP occur between June 15th and November 1 or the first significant rainfall, whichever comes first (Flosi et al. 2012). Instream channel excavations would be completed prior to the onset of the rainy season to avoid erosion and run-off of disturbed soils into the stream. If work involves soil excavation adjacent to the active stream channel after October 15th, work sites would be "winterized" at the end of each work day to reduce the chance of erosion and run-off in the event of an unexpected rain storm. Winterizing, seasonal timing and other best management practices would be implemented to reduce short-term adverse effects on listed salmonids from erosion.

Stream flow would be diverted around the construction area in the steeper sloped channel reaches. Coffer dams may be needed for diversions. Pumps would be used to dewater construction areas during channel relocation and installation of wood structures. Sediment-laden waters from the work area would be treated to remove excess suspended sediment before being discharged back into the stream and wetland. Erosion and sediment control would comply with the 2003 California Stormwater Quality Association Best Management Practice Handbook Construction (CASQA 2003).

Fish screens would be installed prior to excavation at four potential locations and removed at the completion of construction. If threatened fish are discovered within the project area, they would be relocated from the construction area if a temporary clear-water bypass is needed.

Wetland Monitoring— The NPS established two water surface elevation monitoring stations near the downstream extent of the project in 2010. Fifteen additional stations were established in 2013 to assess the effects of this project on water levels and plant communities in the wetland. The NPS will monitor the area for five years.

OTHER ALTERNATIVES CONSIDERED

Other preliminary options considered during planning included removal of additional stream crossings upslope of Strawberry Creek, and restoration of additional lengths of the stream channel. These actions were determined to exceed the potentially available funding or to have relatively little benefit to watershed and stream functions and fish.

Additional Upslope Watershed Restoration— NPS resource management staff identified 25 sites within the upper Strawberry Creek watershed that could potentially affect the stream downslope through erosion of almost 3,000 cu yd of unstable fill (table 2; RCWG 2006a). These 25 sites are located on abandoned logging roads and on the park's West Side Access Road.

Unstable fill would be removed from stream crossings at 12 of the 25 sites, and the stream channels restored to resemble their original configuration as closely as possible. On the 13 remaining sites, culverts would be replaced to upgrade the road to current standards.

TABLE 2. ADDITIONAL UPSLOPE WATERSHED RESTORATION PROPOSALS

Potential erosion and sedimentation threats	
Total number of potential worksites	25
Total estimated volume of erosion potential (does not include debris torrents)	2,974 cubic yards
Total number of sites with debris torrent potential	17
Number of sites with debris torrent potential greater than medium	11
Potential treatment needs	
Number of sites prescribed for road decommissioning	12
Number of sites prescribed for road upgrading (culvert replacement) sites	13

Source: Redwood Creek Watershed Group, March 2006a

More extensive channel restoration–An alternative was considered in which the stream channel excavation and restoration would continue upstream of the proposed project to the east past the SOC ranger residence to the confluence with Morrison Creek, a small tributary of Strawberry Creek draining the slope on the east side of the project area.

Restore stream and floodplain to historical condition–This alternative would restore all of the Strawberry Creek tributaries and the associated Sitka spruce forest on an additional 25 ac currently covered with reed canary grass and other invasive and native herbaceous species. This alternative was not analyzed because the cost would significantly exceed the potentially available funding needed to construct an engineered channel and maintain the restored channel free of reed canary grass.

ENVIRONMENTALLY PREFERABLE ALTERNATIVE

The Council on Environmental Quality's National Environmental Policy Act (NEPA) regulations and the National Park Service NEPA guidelines require that "the alternative or alternatives which were considered to be environmentally preferable" be identified (40 CFR 1505.2). Environmentally preferable is defined as "the alternative that will promote the national environmental policy as expressed in NEPA's Section 101. Ordinarily, this means the alternative that causes the least damage to the biological and physical environment; it also means the alternative that best protects, preserves, and enhances historic, cultural, and natural resources." (CEQ 1981) The environmentally preferable alternative is based on an evaluation of the alternative using the criteria identified in Section 101 of the NEPA stated below:

- Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;
- Assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings;

- Attain the widest range of beneficial uses of the environment without degradation, risk of health or safety, or other undesirable and unintended consequences;
- Preserve important historic, cultural and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity, and variety of individual choice;
- Achieve a balance between populations and resource use which will permit high standards of living and a wide sharing of life's amenities; and
- Enhance the quality of renewable resources and approach maximum attainable recycling of depletable resources.

The NPS has determined that Alternative 3 (More Extensive Restoration) is the environmentally preferable alternative. Compared to the proposed action (Alternative 2), Alternative 3 would restore an additional 450 feet of the Strawberry Creek tributary above SOC, replace an additional undersized culvert through which that tributary flows which would increase the amount of fish habitat, and remove an old log stringer bridge to restore original conditions. These actions would increase the amount of designated critical habitat accessible to SONCC coho salmon and NC steelhead trout.

Alternative 3 (more extensive restoration) would include

- restoring stream habitat by removing invasive plants to create a free-flowing stream channel;
- re-establishing instream fish cover by placing large wood debris in the restored channel;
- increasing habitat diversity by planting riparian vegetation along the new stream channel; and
- reducing the threat of erosion from unstable road fill that increases stream sedimentation and reduces water quality through input of fine sediment.

Compared to more extensive restoration under Alternative 3, the proposed action (Alternative 2) is not the environmentally preferred alternative because 450 feet fewer of stream channel upstream of the SOC Road culvert would be restored, the undersized SOC Road culvert that has been determined to be barrier to passage of anadromous fish would not be replaced, and the old log stringer bridge would not be removed and the area restored to natural conditions. Although the proposed action includes actions similar to the more extensive restoration alternative, more extensive restoration is economically infeasible given available funding for both implementation and future maintenance of the constructed channel and plantings. The proposed action meets the purpose and need of the project to restore habitat for threatened fish at a lower cost compared to the more extensive restoration alternative. The habitat quality of the additional 450 feet of stream channel upstream of the SOC Road that would not be restored under Alternative 2 would not be as high as the habitat in the main channel and West Tributary. Future channel restoration within the wetland area through removal of invasive plants and restoration of an additional 450 feet of stream channel in the reach upslope of SOC would not be precluded under the proposed action.

The no-action alternative is not the environmentally preferred alternative because it would not restore habitat for threatened fish species; would not restore more natural hydrological function of Strawberry Creek; would not reduce the potential for sediment delivery into the stream from eventual failure of the culverts under SOC Road and the West Tributary; and would not remove the stream crossings upslope of the wetland and restore the historic landform and hydrologic functions. The stream crossings would continue to erode gradually and are likely to fail eventually. Sediment would continue to be delivered into West Tributary either slowly through gradual erosion or from more intensive stream-crossing failures. The sediment delivered into West Tributary would move downstream and further degrade the quality of rearing habitat for steelhead trout and threatened coho salmon. Original stream and riparian functions and values would continue to be degraded by the presence of invasive plant species and lack of a clearly defined stream channel.

CONSULTATIONS WITH OTHER AGENCIES

Clean Water Act—The U.S. Army Corps of Engineers (Corps) regulates several types of activities in waters of the United States, which includes navigable waters, tributaries to navigable waters, special aquatic sites (e.g., wetlands), and areas that are "adjacent" to navigable waters. These waters are regulated under Section 404 of the Clean Water Act of 1972, as amended (33 USC Section 1344 *et seq.;* 40 CFR Part 328.3) or Section 10 of the Rivers and Harbors Act (33 USC Section 403).

The NPS performed a wetland delineation in 2009 (Denn and Wagner 2011). Park staff met with the Corps Eureka Office restoration specialist on November 15, 2011 to discuss permitting requirements for potential effects to wetlands from the proposed restoration. The NPS submitted an application to the Corps on November 19, 2012 (Corps File Number 2009-00041) for a Department of the Army permit ("Section 404 permit"). The Corps verified current site conditions through a field investigation on January 31, 2013, review of available digital photographic imagery, and a review of other data included in the NPS application for a permit submitted to the Corps on November 19, 2012. The Corps certified the wetland delineation map for the project site on April 3, 2013. The Corps issued a Department of the Army Permit No. 2009-0041N on January 3, 2014 to the NPS for proposed Strawberry Creek restoration actions.

The NPS will apply to the North Coast Regional Water Quality Control Board (NCWQCB or Water Board) for a Clean Water Act Section 401 Water Quality Certification (401 certification) upon completion of the environmental analysis process. The Water Board requires that environmental analyses comply with the California Environmental Quality Act (CEQA) in addition to NEPA. This EA will be submitted to the California Office of Planning and Research (state clearinghouse) under the CEQA Guidelines: 15225 Section 2. Greenhouse gas [GHG] emissions and growth-inducing impacts have been analyzed in this EA.

Endangered Species—Two federally-listed threatened salmonids occur within the general project vicinity—the Southern Oregon/Northern California Coast coho salmon (SONCC coho, *Oncorhynchus kisutch)* and the Northern California steelhead (NC steelhead, *O. mykiss*). Coho salmon are also listed as endangered under the California Endangered Species Act (CESA). Neither of these species occurs within the project area itself. NC steelhead are known to occupy Strawberry Creek downstream of the NPS project area. A third anadromous salmonid also federally listed as threatened, the California Coastal Chinook salmon (CC Chinook, *O. tshawytscha*), occupies the Redwood Creek estuary downstream of the project area but is not known to occur in the NPS Strawberry Creek project area.

The NPS engaged in regular discussions and conducted numerous site visits with the USFWS and NMFS for all phases of planning for this project.

The NPS initiated consultation with USFWS and NMFS to discuss potential effects of this project on listed threatened and endangered species on August 15, 2007 at an Interagency Consultation Team (ICT) streamlining meeting. (The ICT includes biologists and resource specialists from the NPS, USFWS, NMFS, and CDFW, and meets quarterly to discuss park proposals that have the potential to affect threatened and endangered species.) CDFW biologists from the local area also attended this meeting. A more detailed version of the project was presented in November 2008 to the USFWS. Park staff conducted a site visit to inspect upslope stream crossings on November 20, 2008 and January 29, 2009. Based on these discussions and site visits, the NPS conducted informal consultation with the USFWS.

Informal consultation with NMFS on the proposed action continued at ICT meetings on February 26, 2008; February 10 and November 10, 2009; and August 4 and November 3, 2010. An interagency field review took place on April 24, 2012 to discuss the potential effects of project-generated turbidity on listed salmonids.

Informal consultation by park staff with USFWS is complete for the northern spotted owl and marbled murrelet, the federally listed species that could potentially be impacted by the proposed action. The federal candidate fisher and state-listed bald eagle also were included in the May 2, 2009 *Biological Assessment of Impacts to Terrestrial Threatened, Endangered and Candidate Species from the Streelow Creek Trail Improvements, Tall Trees Trail Reroute and Strawberry Creek Watershed Restoration Projects in Redwood National and State Parks* (Schmidt and Bensen 2009). NPS made determinations of “no effect” to marbled murrelets and “may affect but not likely to adversely affect” northern spotted owls based on the proposed restoration actions.

On June 9, 2009, the USFWS Arcata Fish and Wildlife Office issued a letter of concurrence (file code 8-14-2009-3622 81331-2009-I-0105) with the NPS determination that the proposed action for restoration of Strawberry Creek would not affect marbled murrelets because it would not degrade or remove marbled murrelet nesting habitat and would not disturb marbled murrelets because no project-generated noise would occur in or within 0.25 miles of suitable nesting habitat between March 24 and September 15. The

USFWS concurred with the NPS determination that the proposed action may affect but is not likely to adversely affect northern spotted owls because the total area of suitable nesting and roosting habitat degraded would be approximately 2 ac spread between the four stream crossings and the length of the haul road to be removed; trees removed will be less than 18 inches diameter at breast height (dbh); no potential nest trees will be removed; habitat suitability and function will be maintained; and down logs will remain on-site. No injury or harm to spotted owls is anticipated because no trees will be cut in suitable nesting or roosting habitat from February 1 through September 15.

The project is within the NMFS jurisdictional area covered under the NOAA's Restoration Center (NOAA RC) Biological Opinion and Essential Fish Habitat (EFH) consultation dated March 21, 2012 (2011/06430). On December 4, 2012, the NPS submitted an "Application for Inclusion in the NOAA RC Arcata Office Programmatic Biological Opinion." On January 31, 2013, NMFS determined that the Strawberry Creek restoration project area fits within the scope of that program and would be covered under Section 7a2 of the Endangered Species Act using the Corps permit as the Federal nexus. The Biological Opinion pertains to NOAA RC proposed funding and Corps proposed permitting of restoration projects within the NMFS' Northern California Office jurisdictional area. The Biological Opinion covers the following activities that would be undertaken as part of the Strawberry Creek restoration: instream habitat improvements; instream barrier modification for fish passage improvement; bioengineering and riparian habitat restoration; upslope watershed restoration; and creation of off-channel/side-channel habitat features. Through the programmatic biological opinion, NMFS determined that these proposed activities are not likely to jeopardize the continued existence of SONCC coho salmon or NC steelhead, and are not likely to result in the destruction or adverse modification of designated critical habitat for these species. NMFS expects that the activities will result in incidental take of these species related to dewatering, fish relocation activities, and instream construction activities. The NOAA RC Biological Opinion authorizes incidental take for effects on listed fish related to these activities. The NMFS incidental take statement includes non-discretionary reasonable and prudent measures and terms and conditions that are expected to reduce the amount or extent of SONCC coho salmon and NC steelhead. Two additional discretionary conservation recommendations are also provided. NMFS concluded that the proposed activities would adversely affect EFH for coho salmon, but that the activities would be conducted using adequate measures to avoid, minimize, mitigate, or otherwise offset the adverse effects to EFH.

NMFS concurred with the NPS determination in the biological assessment submitted as part of the Application for Inclusion that the location and proposed timing of the project would not affect the CC Chinook salmon that occupy the Redwood Creek estuary and upstream reaches of Redwood Creek outside the project area, or designated critical habitat for CC Chinook salmon.

The NPS would implement this project in partnership with PCFWWRA, which has received funding for Strawberry Creek restoration through the California Department of Fish and Wildlife Fisheries Restoration Grant Program (CDFW FRGP grant number

P1110508). Projects funded under the FRGP require compliance with Section 1600 of the California Fish and Game Code. Although projects undertaken by a federal agency on federal lands are exempt from compliance with Section 1600, the FRGP grant provides coverage under Section 1600 for the project, including the portion on federal lands in Redwood National Park. NCWQMB 401 certification also requires 1600 compliance.

Cultural Resource and Tribal Consultations—Federal agencies are required to consider the effects of their proposed actions on properties listed in, or eligible for inclusion in, the National Register of Historic Places (i.e., Historic Properties), and allow the Advisory Council on Historic Preservation a reasonable opportunity to comment under the National Historic Preservation Act of 1966, as amended (NHPA), and its implementing regulations found at 36 CFR 800. The regulations require agencies to consult with Federal, state, local, and tribal governments/organizations, identify historic properties, assess adverse effects to historic properties, and negate, minimize, or mitigate adverse effects to historic properties while engaged in any federal or federally assisted undertaking.

The NPS has consulted with the American Indian community since 1978. Initial consultations were conducted with five American Indian heritage advisory committees representing different geographic areas of the parks and different Indian groups. In the 1990s, consultations shifted from heritage advisory committees to tribal governments.

The project area is within ancestral territory of the Yurok people. The Yurok Tribe of the Yurok Reservation, California; Coast Indian Community of Yurok Indians of the Resighini Rancheria, California; Big Lagoon Rancheria of California; and Cher-Ae Heights Indian Community of the Trinidad Rancheria, California are federally recognized tribes. The NPS consults with these tribes on projects within Yurok ancestral territory.

The NPS initiated consultation with the Yurok Tribe’s Culture Committee on February 27, 2009 regarding the project location. No specific concerns were raised at that time. The committee agreed by consensus that the project was consistent with Yurok Tribal values. NPS staff consulted with the committee on December 17, 2010 about proposed geotechnical test pits and auger testing related to the project. The committee inquired about the purpose of the study and why the existing creek wasn’t good enough for fish. It was explained that the current channel does not have the physical characteristics suitable for fish habitat and that the purpose of the project was to restore fish habitat. NPS staff indicated to the committee that final design plans would be shared with the Yurok Tribal Heritage Preservation Officer (THPO) upon finalization. The committee again supported the project as being consistent with Yurok values, and no additional cultural concerns were raised about the project or project location.

The NPS initiated consultation with the Yurok THPO under the government-to-government relationship formalized in a March 2009 general agreement and the provisions of the Tribal Self-Determination Act of 1994 and the California state historic preservation officer (SHPO) on January 15, 2010. In addition, NPS sent letters dated January 15, 2010 to the Yurok Tribal Historic Preservation Officer, Resighini Rancheria, Big Lagoon Rancheria, and the Trinidad Rancheria soliciting input on the project through the NEPA process. No comments were received.

The NPS identified three cultural resources in the study area. None of these resources was determined eligible for listing in the National Register of Historic Places. In consultation with the Yurok Tribe it was determined that restoration of Strawberry Creek would be consistent with Yurok values. The NPS submitted a determination of “No Historic Properties Affected” from the proposed action to the SHPO on November 21, 2013, in accordance with 36 CFR 800.5. The SHPO concurred with the NPS determination in a letter (reference NPS100125A) dated December 23, 2013.

AFFECTED ENVIRONMENT

PROJECT AREA OVERVIEW

Strawberry Creek enters the Redwood Creek estuary at the South Slough. The South Slough was the last meander of Redwood Creek before it was cut off from the creek by the levees of the Redwood Flood Control Project completed in 1968. The headwaters of Strawberry Creek are within Redwood National Park. The creek flows westerly through park land after reaching the valley floor and then through private agricultural and residential lands. It flows under Highway 101 through a concrete box culvert and then through agricultural and residential lands and the Humboldt Country refuse transfer station before entering the South Slough. The western half of the South Slough is within Redwood National Park, a coastal strip approximately 2000 feet wide in this area; the eastern half is within private ownership.

CLIMATE

The Pacific Ocean is a moderating influence on the climate of the park in general. The park has wet, mild winters and relatively dry summers with frequent coastal fog. Most rain falls between November and March, although it can rain any time. Annual rainfall averages 65 inches in the project area. Winter storms from the Pacific Ocean, particularly warmer storms from lower latitudes, bring intense rainfall over several hours or days. These storms may cause both small streams and Redwood Creek to flood, particularly if there has been snow in the higher elevations. Snow in the higher elevations in the upper reaches of Redwood Creek followed by heavy rainfall has caused major flooding in the Orick valley.

Temperatures vary only slightly from summer to winter along the coast. Mean daytime temperatures at Prairie Creek Redwoods State Park near Orick are 47°F in January and 59°F in June. Temperatures above 70°F or below freezing are rare in the project area but more common in inland areas such as the Bald Hills and Little Bald Hills.

The prevailing winds come from the northwest or south-southwest and are generally light. Intense winter storms may be accompanied by damaging winds.

Fog is a dominant climatic feature in the project area, generally occurring daily in the summer and not infrequently during the rest of the year.

Global climate change is predicted to cause sea-level rise. Sea level is predicted to rise by of 1.4 meters (55 inches) by the year 2100 using current models (Pacific Institute 2009a, b; National Academies of Science 2014). The base level of Strawberry Creek at the South Slough is about 5 feet above current mean sea level.

AIR QUALITY

Air quality in RNSP is considered good to excellent because of the low population, scarcity of pollutant sources, and prevailing westerly ocean winds. Views in the project area are often obscured by fog, rain, low clouds, salt spray haze, and natural forest haze inversion.

Redwood National Park is designated as a class I airshed pursuant to Part C of the Clean Air Act, as amended (42 USC 7401 *et seq*.). Class I designations are given to areas where air quality is cleaner than the national ambient air quality standards. Class I areas have the most stringent regulations for the protection of air quality, permitting the lowest increments of air quality degradation.

The parks are assigned to the North Coast Air Basin by the California Air Resources Board, which is under the jurisdiction of the North Coast Unified Air Quality Management District. Federal standards are consistently achieved, including those for ozone, $PM_{2.5}$ (particulate matter less than 2.5 micrometers in diameter), PM_{10}, carbon monoxide, nitrogen dioxide, sulfur dioxide, sulfates, and lead. The air quality in the project area meets California standards for these pollutants, as well as state standards for visibility reducing particles. Humboldt County is a non-attainment area for state standards for PM_{10}. The most significant air pollutant in the parks is PM_{10}, which is primarily produced from widespread nonindustrial burning such as burn barrels, woodstoves, and vegetation burn piles; industrial burning of timber harvest slash piles; and prescribed burning on federal and state lands for hazardous fuel reduction. In the past, total suspended particulates exceeded air quality standards, but improved technology, better use of materials, and fewer sawmills (especially their teepee burners) in the region have resulted in a reduction in suspended particulates.

Since 2000, the NPS Air Resources Division has operated a monitoring station at the former park maintenance area at Requa for visibility that measures fine ($PM_{2.5}$) and coarse (PM_{10}) particle mass, elements, sulfate, nitrate, and organic and elemental carbon. An ozone and meteorological monitoring site operated in the parks between 1987 and 1995. Other monitoring stations are in Crescent City and Eureka.

The largest source of greenhouse gasses (GHG) in RNSP is emissions from mobile combustion, primarily vehicles burning fossil fuels (RNSP 2011). Non-park sources of transportation-related mobile combustion also contribute to GHG levels adjacent to the project area.

GEOLOGY AND TOPOGRAPHY

Strawberry Creek historically flowed northward through an expansive wetland system into the lower portions of Redwood Creek estuary. The historical flow pattern and the associated floodplain have been significantly modified by relocating and ditching of the channel along nearly the entire valley wall south of Orick and a levee system constructed in the lower portions of Redwood Creek after the December 1964 flood.

The Orick valley and the surrounding landscape are part of the California Coast Ranges, which were formed over the last several million years in response to crustal shortening associated with compression between the Pacific and North America tectonic plates. The Mendocino triple junction represents the intersection of three crustal plates; the North American plate, Pacific plate, and Gorda plate. The junction is located approximately 60 miles south of the town of Orick. North of the triple junction, the Gorda plate is being actively subducted beneath the North American plate along the Cascadia Subduction Zone.

The topography within the project area is controlled by fluvial processes and landforms associated with Redwood and Strawberry Creek. The primary landforms are the alluvial fan deposited by Strawberry Creek as it flows onto the adjacent, low gradient Redwood Creek floodplain. The proximity of abandoned Redwood Creek meander scars suggests that the distal extent of the Strawberry Creek alluvial fan may have been truncated as Redwood Creek meandered across its floodplain. The Strawberry Creek floodplain appears to occupy the lower extent of its alluvial fan, although this may be a result of channeling and ditching efforts over the past 80 years. The parent material of these landforms grade from alluvium (stream deposits) and modified colluvium (debris flow deposits) to silt and organic materials within the floodplain.

The hillslopes above Strawberry Creek are underlain by Redwood Creek schist of the Franciscan Complex, a Jurassic to Cretaceous age, low grade meta-sedimentary and meta-volcanic bedrock unit of the Franciscan Complex. Redwood Creek schist forms a northwest trending bedrock belt bound on its west side by the Bald Mountain fault, and on the east side by the Grogan fault. The Franciscan Complex rocks laid down on the ocean floor as deposits of sand and mud about 150 to 100 million years ago. These deposits were carried eastward on the oceanic plate, accreted to the North American continent, and eventually uplifted to as part of the Coast Range. Through time and ongoing tectonic activity selected sand and mud deposits were lithified to sandstone and mudstones and then altered by heat and pressure beneath the earth’s surface to schist.

The project area is underlain by Quaternary alluvium consisting of overbank deposits that are predominantly firm sandy loam and silt loam (Harden et al. 1981).

GEOLOGIC HAZARDS

The Cascadia Subduction Zone (CSZ) is the most significant potential seismic source in the region, capable of generating earthquakes as great at magnitude 9.0. The recurrence interval of such an event is estimated at 300 to 500 years. Evidence suggests the last magnitude 9.0 or greater earthquake on the CSZ occurred approximately 300 years ago around 1700. A large earthquake along the CSZ could damage structures in the Orick valley through ground shaking, as well as generate ground failures related to liquefaction and activation of road fill slope failures and landslides. Soils and sediments most susceptible to liquefaction are weakly consolidated silts and sands saturated by groundwater similar to those in the project area.

Orick occupies a low-elevation coastal valley onshore of the CSZ and is associated with a high tsunami inundation hazard. Tsunamis are sea waves caused by abrupt, large-scale land level changes on the ocean floor. The disturbance at the ocean floor generates a series of waves that propagate through the entire water column. These waves can be as high as 30 to 100 or more feet when breaking on shore. The area appears to have been inundated during the last Cascadia event in 1700. Available tsunami inundation mapping (Redwood Coast Tsunami Working Group 2012) distributes hazard maps that show the Orick area within an inundation zone.

SOILS

The Redwood National and State Parks Soil Survey (USDA-NRCS 2008) provide generalized baseline information on soils within the project area. Soil maps at 1:24,000 scale identify four soil map units in the project area (figure 2). Each soil map unit is named for the dominant soil type(s), and includes other soil types known as minor components, which are of limited extent (table 3).

Soils in the project area are primarily Aquepts and Udepts formed in sediments deposited in the valley by Redwood Creek (prior to levee construction) and Strawberry Creek and their tributaries. Soil textures range from very gravelly loams on the higher parts of alluvial fan, to silty clay, peat and muck on the floodplain adjacent to active channels. Variation in texture probably reflects how the soils were deposited. During flooding, Redwood and Strawberry Creeks overtop their banks and deposit sediments on the alluvial fans and floodplain. The coarse sediments, gravel and sand are deposited first atop the alluvial fan and natural levees as the flood waters lose velocity and turbulence. Finer sediments, grading from fine sandy loam to silty clay loams are deposited further away from the channels. As floodwaters recede and velocity slows, finer sediment is deposited in depressions. Textures in meander scars and depressions range from silty clay to muck.

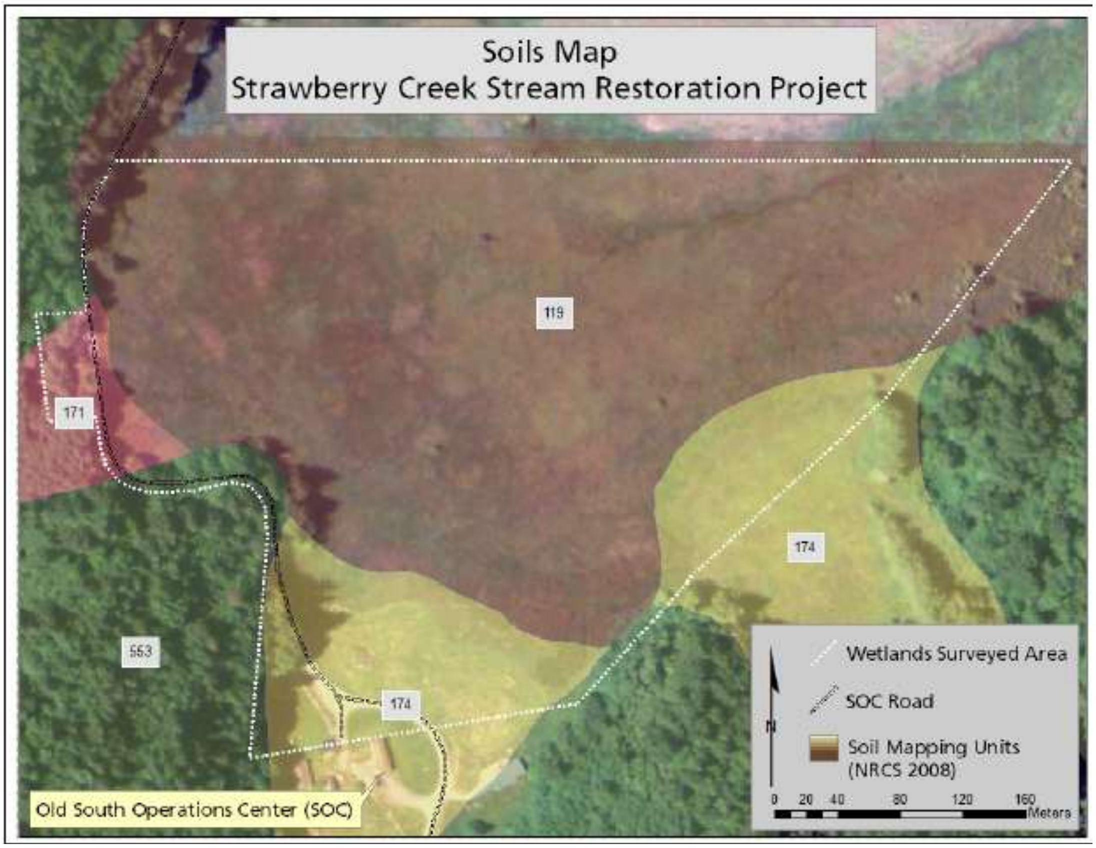

Figure 2. Soil map units

TABLE 3. SOIL MAP UNITS AND SOIL COMPONENTS OF PROJECT AREA

Map Unit Symbol	Soil Series (type)	Soil Classification (suborder)	Hydric Status	Compo-sition (%)	Landform
119	Arlynda	Aquepts	Hydric	85	Backwater channels, meander scars
	Weott & Worswick	Aquepts	Hydric	15	Adjacent to channels, levees
171	Arlynda	Aquepts	Hydric	40	Floodplain
	Worswick	Aquepts	Hydric	35	Floodplain
	Dystrudepts	Udepts	Non-hydric	10	Lower hillslopes, terraces
	Endoaquepts	Aquepts	Hydric	10	Floodplain
174	Bigtree	Udepts	Non-hydric	50	Alluvial fans
	Mystery	Udepts	Non-hydric	25	Alluvial fans
	Dystudepts	Udepts	Non-hydric	10	Alluvial fans
	Endoaquepts	Aquepts	Hydric	15	Channels and depressions
545	Devilscreek	Udepts	Non-hydric	45	Headwalls of debris slides
	Panthercreek	Udepts	Non-hydric	20	Debris slides
	Coppercreek	Humults	Non-hydric	15	Hillslopes
	Minor components	Udepts	Non-hydric	20	Hillslopes
553	Ladybird	Humults	Non-hydric	60	Hillslopes
	Stonehill	Humults	Non-hydric	20	Hillslopes
	Udepts	Udepts	Non-hydric	15	Unstable hillslopes
	Fluvents	Fluvents	Hydric	5	Active channels

On-site soil information was derived from 12 hand-dug soil pits, eight borings and examination of numerous bankcut exposures from 2008-2012. The locations were chosen to characterize hydric soils, wetland extent and the geologic materials likely to be encountered during project implementation. Soil pits were excavated to a depth of 1 meter and then an auger was used to a depth of 1.5 meters. Soil boring depth ranged from 1 to 3 meters.

Soil pits and borings indicate that soil patterns are much more complex than the soil map depicts.

The alluvial fan in the southern and eastern portions typically consist of 1–1.5 meters of loams to subangular gravelly loams, with depth to seasonal high water table varying from 1.5 meters or greater to 0.5 meters along the distal margins adjacent to the floodplain. Overall the floodplain pits and borings consist of muck or peats overlying lenses of sand to gravelly sand interlayered with thick deposits of silt loams to silty clays and layers of peat or muck. The boundaries between soil layers are sharp, occurring in less than 5mm, and at a few locations, appear to overlie a weakly developed, buried surface soil horizon.

An unidentified soil exists within the 119 mapping unit that is not evident on the NRCS soils map or the descriptions in table 3. Within a large portion of this mapping unit (more than 50% within the surveyed area), surveyors observed a “floating mat” of poorly-decomposed, graminoid (grass and sedge) fiber. A sample taken near the center of the mat indicated an approximate depth of 40 cm of organic matter floating on approximately 45 centimeters of free water over a highly reduced silty clay.

WATER RESOURCES, INCLUDING HYDROLOGY AND WATER QUALITY

Overview

The Strawberry Creek project area includes about 1,700 linear feet of stream channel and adjacent floodplain within the park; the total length of the creek is about 9,000 feet. The East, West, and SOC tributaries form the three main forks of the headwaters of Strawberry Creek. The three forks join on park property. The lower creek flows through livestock pasture and in a culvert underneath Hiltons Road before crossing under Highway 101 in another culvert. Downstream of the highway, the creek flows through the Humboldt County waste transfer station and livestock pasture before entering the South Slough of Redwood Creek.

Hydrology

Strawberry Creek drains an area of about 1,400 ac (2.2 sq mi) at its confluence with the South Slough (table 4). Several tributaries meet at the base of the hillslope along the southeastern edge of the Orick valley to form the main stem of Strawberry Creek near the SOC (figure 3). Table 4 shows hydrographic data for hydrologic sub-units of the project area depicted in figure 3. Total channel length (from the headwaters of the East Fork to the South Slough) is roughly three miles and blueline streams total about 3.4 miles in combined length. Elevations in the watershed range from 10 to about 1,250 feet (National Geodetic Vertical Datum 1929, NGVD29). Most of the 1,240 feet of relief exists within the hillslope portion of the watershed adjacent to the valley floor. Headwater tributaries are short (2,000 to 3,000 feet long) and steep (30%-40% gradient). Channel gradient changes abruptly from 30% to roughly 0.2%, more than a hundred-fold decrease. The South Fork tributary joins with Strawberry Creek about 0.1 mile north of SOC (figure 3).

Figure 3. Color infrared air photo of Strawberry Creek, October 1983. Open water within the Redwood Creek levees shows as black; wet marshy areas show as dark red.

TABLE 4. HYDROGRAPHY OF STRAWBERRY CREEK WATERSHED

Name or Description of Sub-Watershed	Drainage Area (mi^2)	Length of blue-line streams (mi)
East Fork headwater slopes	0.63	0
South Fork	0.39	0.61
West Fork	0.21	0.49
North Fork	0.21	0
East Valley Floor (east of U.S. 101)	0.42	1.48
West Valley Floor (west of U.S. 101)	0.33	0.79
Totals	2.19	3.37

Strawberry Creek is a perennial creek. It is not gaged for discharge; flow regime and flooding characteristics are estimated from available information. In June 1988, the flow was estimated at 1.5 cubic feet per second (cfs) while in August 1989, flows were estimated at 0.25 cfs. Minimum flow is usually reached in September, and is estimated to be typically 0.5 cfs or less. Average annual flow for Strawberry Creek is estimated at about 6 cfs, calculated using an annual precipitation of 65 inches measured at the RNSP rain gage located within Strawberry Creek watershed. No high flow measurements are available for Strawberry Creek, but the 25-year flood at the U.S. Highway 101 bridge is estimated to be 180 cfs. Flood peaks are attenuated (reduced in magnitude and broadened in time) by the dispersal of flows on the valley floor; thus, the actual peaks may be of lower magnitude in downstream reaches on the valley floor compared to reaches farther upstream.

Strawberry Creek's steep headwater tributaries respond quickly to rainfall and deliver water efficiently to the channel on the valley floor. Where the gradient flattens out on the valley floor, velocities decrease abruptly. The channel becomes poorly defined because of the absence of continuous banks and flows become dispersed over a wide area due to the proliferation of invasive grasses which now choke stream channels and exacerbate flooding on adjacent pastures.

Since May 2010, the NPS has maintained two water surface elevations monitoring stations near the downstream extent of the project area, one in the channel at the northern NPS property boundary (well B), and another nearby on the adjacent Palustrine Emergent wetlands (well C). Figure 4 shows a plot of water surface elevation data and cumulative precipitation at nearby Orick gage. As depicted, water levels in the Palustrine Emergent wetlands are always higher than those in the creek, and both areas respond relatively quickly to rainfall. The magnitude of response in the channel is larger, i.e., storm peaks rise by greater amounts than in the marsh, though still small. The approximate winter-high water to summer low-water level is 0.6 ft (range 19.8–19.2 ft) in the channel compared to 0.4 ft (range 20.2–19.8) in the adjacent wetlands. In 2013, the NPS established an additional fifteen stations to monitor the effects of the project on water level and plant communities. Monitoring will occur for five years.

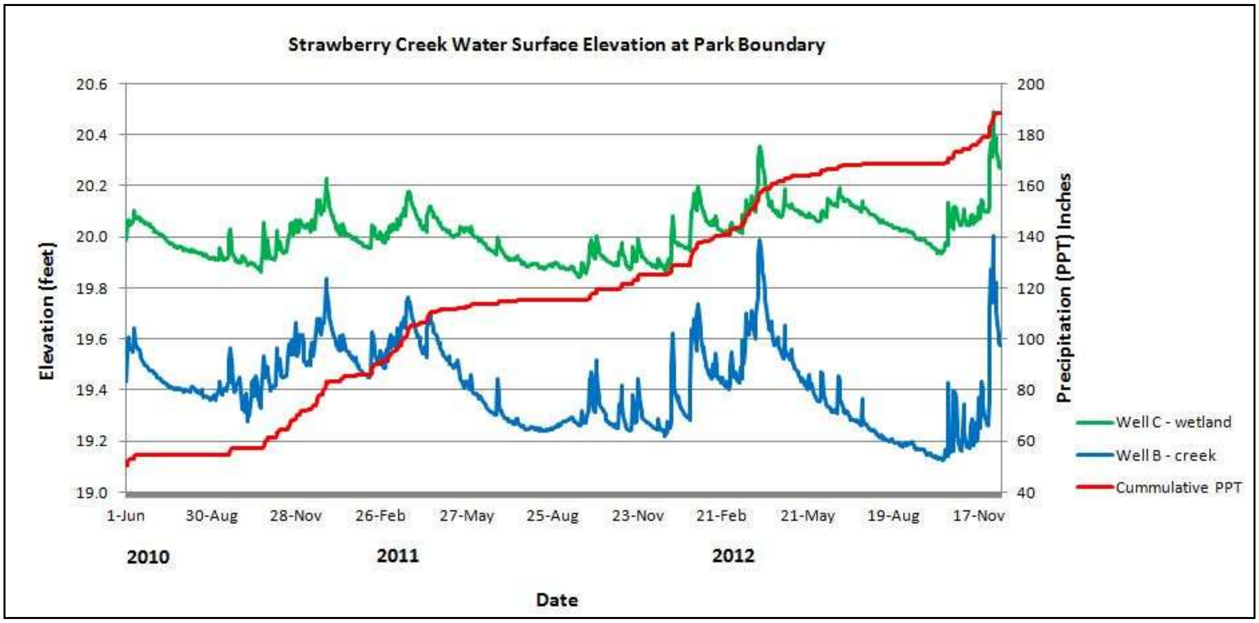

Figure 4. Plot of water surface elevation (feet) in well B and well C and cumulative precipitation (inches). Well B is located in Strawberry Creek channel directly upstream of the park boundary with adjacent private landowner. Well C is located approximately 100 feet east of well B within a ponded water area of the wetland. Cumulative precipitation on June 1, 2010 was approximately 50 inches.

The maximum water level elevations attained for a 14-day period determines wetland characteristics. Figure 5 shows these elevations for Strawberry Creek. As shown, for the period of record, the maximum 14-day water elevation for the mash area was 20.3 feet (NAVD88).

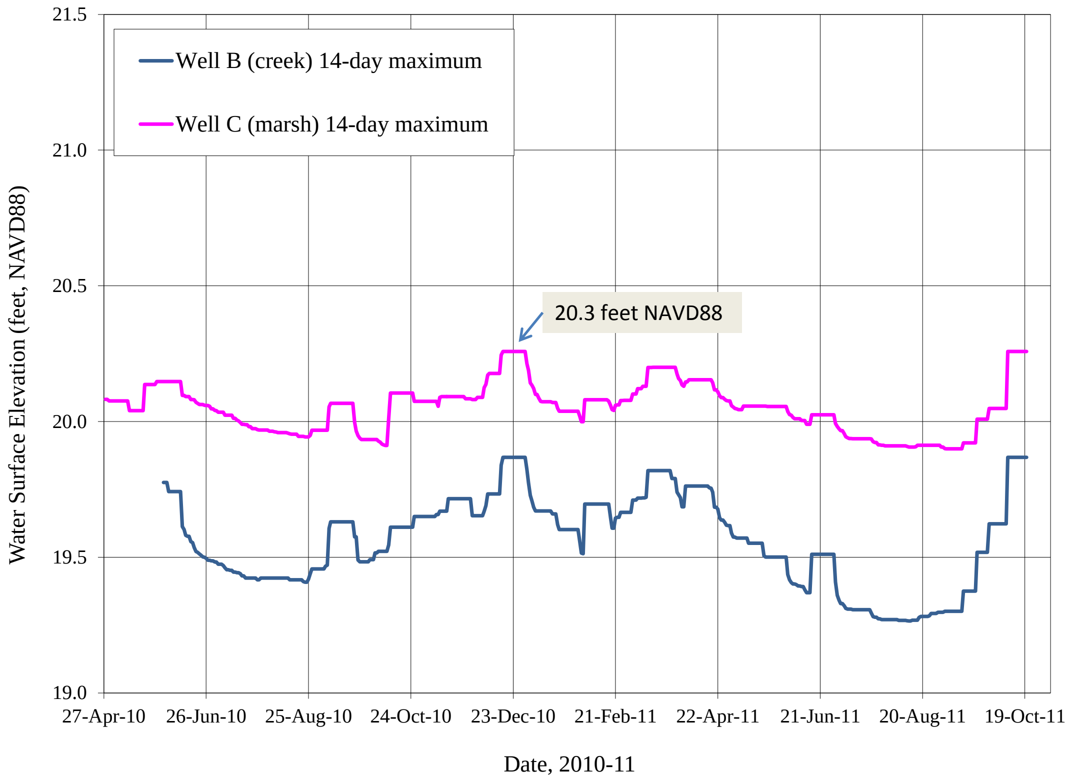

Figure 5. Maximum 14-day water levels in Strawberry Creek and on adjacent wetlands, 2010-11

Water Quality

The most important elements of water quality relative to fish habitat in Strawberry Creek are tannins, turbidity, suspended sediment, dissolved oxygen, salinity, and temperature. Tannins are probably highest during summer and fall when flows are most stagnant, but have little effect on habitat in Strawberry Creek. Turbidity and suspended sediment are closely linked; when suspended sediment is high, so is turbidity, and they are highest during winter storms. Turbidity is assumed to behave in fashion similar to other near-by streams in which turbidity is monitored. Because hillslopes have numerous old erosional features from logging in the 1950-70s, turbidity in the creek may exceed 1,000 NTU [nephelometric turbidity units, a commonly used measure of turbidity] during peak storm conditions, and drop to 0-20 NTU between storms, and to zero through the summer months.

Strawberry Creek is not continuously monitored for water quality, but water quality is measured in coordination with fish distribution sampling at locations located along the creek from just upstream of the SOC culvert to the confluence with the South Slough of the Redwood Creek estuary. The parameters measured are dissolved oxygen (mg/l), salinity ($^{0}/_{00}$), specific conductance (µS at 25°C), and water temperature (°C). Other than at the SOC Tributary culvert, the other sampling locations are downstream and outside of the project area due to the lack of an open defined main stem stream channel within the project area.

Prior to the removal in August and September 2006 of the reed canary grass covering the stream channel reach immediately downstream of the park reach on private property, dissolved oxygen was very low (less than 0.15 mg/l). In comparison, dissolved oxygen in the SOC Tributary, a free-flowing aerated channel, was 8.9 mg/l–9.5 mg/l. After the vegetation was removed, dissolved oxygen in the downstream reach ranged from 3.9 mg/l to 5.7 mg/l in September 2007. Dissolved oxygen peaked in May 2008 and February 2009 at 7.8 mg/l and 8.4 mg/l, respectively. As the reed canary grass mat reformed in the downstream reach, dissolved oxygen continued to decline, reaching 2.9 mg/l in June 2011. At the same time, dissolved oxygen in the SOC Tributary was measured between 9.8 and 11.7mg/l from June 2009 through 2011. Dissolved oxygen at the site below the SOC Road culvert was 10.3 mg/l in May 2012 and was 9.4 mg/l in September. At the wooden bridge site downstream of the park boundary, dissolved oxygen had dropped to 3.6 mg/l in May 2012 and to 6.3 mg/l in September 2012. Dissolved oxygen at the Hiltons Road culvert was 5.3 mg/l in September 2012. Salmonids generally require dissolved oxygen above 7.75 mg/l although they can survive at 5 mg/l. Dissolved oxygen less than 2 mg/l is considered lethal to juvenile fish (Water Quality Assessments 1996).

Salinity has been measured at or near zero ($0.2^{0}/_{00}$) at all the locations in Strawberry Creek, and always $0.0^{0}/_{00}$ at the SOC Tributary and $0.01^{0}/_{00}$–$0.1^{0}/_{00}$ in the Barlow reach downstream of the project site. No estuarine salt water influence has been recorded. Specific conductance similarly is low, ranging from 93µS to 102µS in the SOC Tributary and generally higher, between 75 µS and 180 µS, in the Barlow reach.

Water temperature fluctuates seasonally, with less fluctuation in the SOC Tributary reach. Water temperature is generally cooler in the SOC Tributary than in the Barlow reach, probably a result of the existing riparian vegetation in the SOC Tributary. Temperatures in the SOC Tributary have ranged from 8.7°C to 13.1°C. Temperatures in the Barlow reach between 2006 and 2011 have ranged from 7.9°C to 23.3°C.

FLOODPLAINS

Strawberry Creek follows a valley floor depression that may have been originally formed by Redwood Creek in prehistoric times. During the 1964 and earlier large floods, the entire Redwood Creek floodplain, of which Strawberry Creek floodplain is a part, was inundated. Redwood Creek once meandered back and forth across the Orick valley. The floodplain still shows evidence of these floods and channel migration in the form of back-channels and meander scar depressions (figure 3). Downstream of Highway 101, Strawberry Creek flows across the floodplain created by a large meander of Redwood Creek before entering the South Slough, now a backwater channel connected to the estuary.

Flood control levees completed in 1968 prevent Redwood Creek from migrating across the valley floor or flooding the project area.

Floodplain areas in the vicinity of Strawberry Creek contain features from past and present agricultural use, such as ranch roads, some of which are elevated above surrounding surfaces and composed of imported fill, culverts beneath roads, and stream channels excavated as drainage ditches. These features have altered the hydrology and geomorphology of the creek from natural conditions primarily by: 1) realigning segments of the creek channel, thereby altering channel slope and sinuosity; 2) creating marshy back-water areas upstream of constrictions formed by culverts and areas obstructed by vegetation; and 3) increasing the width/depth ratio over that would be characteristic of this type of channel by over-excavating ditches with the intention of decreasing the frequency of cleaning required to maintain drainage.

Adjacent to the project reach, the floodplain has been converted from seasonally-flooded pastureland to a perennial marsh because of standing or slowly moving water backed up by downstream channel constrictions.

WETLANDS

Some of the most important functions played by wetlands relate directly to the presence and condition of hydrologic processes, including components linked to hydraulics, geomorphology, and hydrodynamics of fluvial or stream and tidal systems. These functions include dissipation of flood flow energy, retention of floodwaters, water quality improvement, carbon export and sequestration, and wildlife habitat. Streams that are able to connect with functioning, vegetated floodplains can buffer humans and wildlife from impacts associated with flooding and poor upstream water quality. In addition, these same areas support wildlife by providing habitat and food within streams and floodplains as well as by exporting food and organisms downstream to larger water bodies. Appendix B describes functions and values before and after restoration.

Soils are integral components of many hydrologic and ecological functions, either directly or indirectly. These functions include water quality improvement, carbon export and sequestration, and wildlife habitat. The ability of soils to bind or retain contaminants and thereby improve water quality is strongly related to texture, e.g., percentage of clays, silts, sands, organic matter (decomposing plant material). Another important parameter of wetland soils is the lack of oxygen. Sustained inundation or saturation of soils by water causes the soil environment to become reduced or anaerobic, which initiates a complex biogeochemical process that helps to lock contaminants into the soils. Once bound to soils, these contaminants are rarely released back into their environment, unless there are drastic changes in wetland conditions such as oxidation of soils due to dewatering. The natural filtering mechanisms of wetland soils have encouraged many municipalities to turn to treatment wetlands to treat wastewater.

In September 2009, NPS wetland scientists surveyed NPS lands that may be affected by restoration actions and delineated wetlands on 38.30 acres in and around Strawberry Creek (Denn and Wagner 2011). The delineations covered wetlands as defined by the

U.S. Army Corps of Engineers under Section 404 of the Clean Water Act (1987 Corps of Engineers Wetlands Delineation Manual and Regional Supplement), the NPS (Cowardin et al. 1979) and the California Department of Fish and Wildlife ("one-parameter" lands) (table 5). The Corps of Engineers Manual uses a "three-parameter approach" in which a site must meet specific hydrology, vegetation, and soil criteria to be considered a wetland. The NPS definition (Cowardin et al. 1979) considers these three-parameter sites to be wetlands, but also includes sites that meet the hydrology parameter but may not be vegetated or have hydric soils due to certain physical or chemical factors.

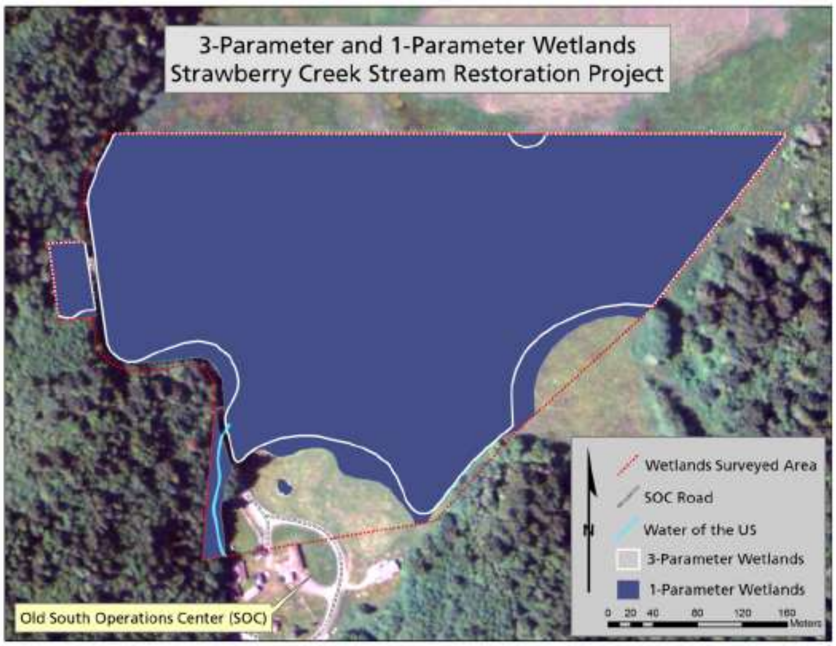

Figure 6. Area surveyed for wetland delineation (Denn and Wagner 2011)

Within the area surveyed by Denn and Wagner (2011), 31.70 acres were mapped as Corps wetlands (table 5). Under the Cowardin system, the NPS considers these 31.70 acres to be wetlands, but includes an additional 0.02 acre of riverine upper perennial habitat (stream channel) as wetlands (table 5). This 0.02 acre is not considered to be wetland habitat by the Corps, but they do regulate it as "other waters of the U.S." under Section 404 of the Clean Water Act. A total of 33.90 acres meet the one-parameter wetland concept recognized by the California Department of Fish and Wildlife.

TABLE 5. ACRES OF WETLANDS WITHIN THE PROJECT AREA

Wetland Type	Acres
Cowardin Wetlands	31.72
Palustrine Emergent	*30.69*
Palustrine Forested	*0.87*
Palustrine Scrub-shrub	*0.14*
Riverine Upper Perennial	*0.02*
[1]Corps (Three-Parameter) Wetlands	31.70
[2]One-Parameter Lands	33.90

1 Cowardin wetlands and Corps three-parameter wetlands coincide except for 0.02 acres of riverine upper perennial (stream) habitat, which the Corps does not recognize as wetland.

2 Includes all Corps/Cowardin wetlands plus an additional 2.2 acres that had hydrophytic vegetation but did not meet hydric soil or wetland hydrology criteria.

U.S. Army Corp of Engineers (Corps) Jurisdictional Wetlands—The Corps regulates several types of activities in waters of the United States, which include navigable waters, tributaries to navigable waters, and many ponds, lakes and wetlands. These waters are regulated under Section 404 of the Clean Water Act (40 CFR 328.3) or Section 10 of the Rivers and Harbors Act (33 U.S.C. 403). Based on the Denn and Wagner (2011) delineation, 31.70 acres of wetlands (three-parameter) and 0.02 acre of other regulated waters (stream channel) subject to Section 404 jurisdiction exist in the project area.

NPS Wetlands—NPS DO #77-1 established policies, requirements, and standards for implementing EO 11990 “Protection of Wetlands” which directs federal agencies to avoid long- and short-term impacts to wetlands. The NPS uses the Cowardin classification system (Cowardin et al. 1979) as the basis for defining, classifying, and inventorying wetlands that are protected by NPS wetland policies and procedures.

Cowardin Wetlands—Wetlands were surveyed on 38.30 acres of park land that may be affected by restoration actions (Denn and Wagner 2011). Within this surveyed area, 31.72 acres were delineated as Cowardin wetlands: Palustrine Emergent (30.69 ac), Palustrine Forested (0.87 ac), Palustrine Scrub-Shrub (0.14 ac), and Riverine Upper-Perennial (0.02 ac) (figure 6).

<u>Palustrine wetlands</u>, commonly known as marshes or swamps, are non-tidal and typically dominated by trees, shrubs, or persistent herbaceous vegetation. These areas generally exhibit high year-round ground or surface water.

Palustrine Emergent wetlands are areas with high year-round ground or surface water that support herbaceous vascular plants at 30% or greater cover in most years, with a tree and shrub cover of less than 30%. Generally in the project area palustrine emergent wetlands represent the peat-forming "floating mat" grass and sedge community described in this report, and also grass, sedge and rush communities on the fringe of the "floating mat" community.

Palustrine Forested wetlands are areas with high year-round groundwater that support a tree canopy of 30% cover or more. In the project area, the two palustrine forested polygons have an overstory of Douglas-fir (*Pseudotsuga menziesii*). The palustrine forested portion on the west side of the surveyed area has a dominant understory of skunk cabbage (*Lysichiton americanum*), while the palustrine forested portion on the east side has a dominant understory of mixed shrub species including California wild rose (*Rosa californica*) and California blackberry (*Rubus ursinus*).

Palustrine Scrub-shrub wetlands are areas with high year-round ground or surface water that are dominated by woody vegetation less than 6 meters (19.6 ft) tall. Within the surveyed area this wetland type is represented by two areas located on disturbed road shoulders and dominated by non-native Himalaya blackberry (*Rubus armeniacus*).

Riverine Upper-Perennial wetlands are shallow (less than 2 meters [6.6 ft] deep at low water), fresh water systems in channels with relatively steep gradients and year-round flow. Within the surveyed area, this wetland type is restricted to the 400-foot long channel of Strawberry Creek immediately west of old SOC. Habitat on the eastern edge of the project area and the west bank against the valley hillslope is not wetland as it lacks wetland soils and hydrology.

VEGETATION

Based on historical photographs and reports from long-time residents of the Orick valley, most of the Strawberry Creek project area was probably dominated by communities of Sitka spruce forest, red alder forest, shrub, and herbaceous wetland communities, intergrading to varying degrees with each other as conditions allowed. The spruce stands would have included two forest types, a dry and wet forest type. The dry spruce stands would have been dominated in the understory by salal, huckleberry, salmonberry and thimbleberry, and would have occurred on elevated slopes above the wetland areas, i.e. the outer edges of the valley bottom and bottom of forested slopes (see Appendix C for scientific and common names for plants in the project area). The wet spruce stands or spruce swamp, would have been dominated in the understory by sedges and skunk cabbage, and would have occurred on the valley bottom, in areas adjacent to or slightly elevated above seasonally inundated water zones.

Alder forests would have occurred along riparian corridors flowing into the valley bottom from the adjacent slopes. These forests would likely have been dominated by an understory of shrubs on slightly elevated locations nearer the valley wall to stands with an understory dominated by sedges and skunk cabbage in the wetter environmental regimes of the valley floor. The spruce and alder vegetation types would have blended seamlessly throughout the majority of the project area with both species in dominant canopy positions as ground and soil conditions allowed.

The drier upland forests above the valley floor to the west, south, and east would have included old growth redwood forests. Redwood trees would have occurred on the valley floor in the project area where the soil was sufficiently elevated above wetland areas to support their growth and maturation.

A shrub community was likely scattered in locations, particularly adjacent to those areas that received more vigorous annual flooding. In these locations willow stands would have dominated with an understory of salmonberry, elderberry, thimbleberry, and sedges in varying densities controlled by hydrologic factors. In some cases, the shrub community may have lacked a willow overstory component and have been dominated by salmonberry, elderberry, and/or thimbleberry.

The flooded wetlands that currently exist in the project area would have been likely composed of multiple wetland vegetation types, including types dominated by submerged vegetation (needing water to remain upright) such as swaying bulrush, to more emergent wetland types including associations dominated by sedges, cattails, and native *Glyceria*. There would have been no overstory of shrubs or trees in these wetlands due to the presence of persistent water and would have appeared as openings in the spruce-alder forests, as viewed from above.

Within the project area today, the complexity of vegetation types has been dramatically altered as a direct result of overstory clearing, water diversion and channelization, and creation of extensive livestock pastures. The current wetlands have primarily been affected by changes in hydrologic function and invasive plant species. While native obligate wetland species persist in the project area, the invasive species have likely suppressed native wetland species below what could be expected in a wetland without invasive species.

The clearing of spruce and alder forests from the project area represents the most obvious change in vegetation patterns. The spruce forests are now present only on the lower portions of the slopes above the valley floor. These forests are typified by almost 60% to 100% cover of overstory conifer trees dominated by spruce, with ferns, shrubs, and herbaceous species growing in the understory at varying densities and cover. The current spruce forests are young, less than 80 years of age, and intergrade with the second growth redwood forests that were also logged.

The red alder stands have also retreated from the valley floor and can be found in one small area within the current proposed project area at the West Tributary. A stand of red alder dominates the riparian zone of the West Tributary, with an understory primarily of skunk cabbage and sedge species.

The shrub community can be found within the project area on slightly elevated slopes, dominated by thickets of Himalaya blackberry, a highly invasive species. Willow-dominated communities no longer exist in the project area. Salmonberry, elderberry, and thimbleberry may still occur in the project area, but mainly as associates of other vegetation types and in combination with the Himalaya blackberry thickets.

The remainder of the project area is dominated by herbaceous vegetation, either by pastures or wetland associations. The pastures in the project area mainly occur south and east of the main SOC Road culvert. These pastures are currently dominated by several introduced grasses and herbaceous species such as Italian ryegrass, redtop, creeping bentgrass, white clover, cut leaf geranium, and creeping buttercup. These species were favored by ranchers to provide forage for livestock, and were planted on more elevated dry ground within the project area. These species are naturalized and while some can be invasive in other areas of the park, there is limited area for expansion in the project area because of the forested slopes to the east, south, and west, and by extensive wetlands to the north.

FISH AND WILDLIFE

Fish listed as threatened or endangered that occupy Strawberry Creek downstream of the project area are described below under *Sensitive, Threatened and Endangered Species.* Other fish observed downstream in Strawberry Creek are prickly sculpin (*Cottus asper*), staghorn sculpin (*Leptocottus armatus*), and threespine stickleback (*Gasterosteus aculeatus*). Electroshocking in 2010 produced only threespine stickleback upstream of the project area and in the West Tributary of Strawberry Creek.

Wildlife species diversity is relatively high among the lowland riparian/wetland area and the forested hillslope above Strawberry Creek and its tributaries. This diversity is likely due in part to the mosaic of habitats and relative structural complexity of the habitats within this area, including some legacy old growth trees, snags, and logs on the hillslope.

The moist cool coastal environment of the project area, along with the wetland and riparian habitats in the project area, favor amphibians. Species that are known to commonly occur in the lower riparian area and wetlands and upland forest include rough-skinned newts (*Taricha granulosa*), which have been observed crossing Hilton Road and captured in Strawberry Creek; coastal giant salamanders (*Dicamptodon tenebrosus*), including neotenic forms that were observed by electrofishing in the west fork of Strawberry Creek; and northern Pacific tree frogs (*Pseudacris regilla regilla*). Coastal giant salamander larvae and northern red-legged frogs (*Rana aurora*) were obtained in samples from the tributary upstream of the project area in the SOC Tributary and in the West Tributary.

Tailed frogs have not been observed in the project area. Strawberry Creek is not likely to currently support populations of tailed frogs (*Ascaphus truei*) because the marshy area downslope and the stream channels on the upslope logged hillsides do not provide good quality habitat. Tailed frogs generally require a stream with a rocky substrate.

Other amphibian species also likely to occur in the project area include western toad *(Anaxyrus boreas*), California slender salamander (*Batrachoseps attenuatus*), Oregon ensatina (*Ensatina eschscholtzii oregonensis*), and northwestern salamander (*Ambystoma gracile*).

Lizards and snakes, although more common in drier vegetation types, may occur in habitats adjacent to Strawberry Creek, and in the forest above the creek. The California red-sided garter snakes (*Thamnophis sirtalis infernalis*) and western terrestrial garter snake (*T. elegans*) may occur here, along with northern alligator lizards (*Elgaria coerulea*) and northwestern fence lizards (*Sceloporus occidentalis*).

Incidental observations of birds by park staff between June 2000 and May 2003 along SOC Road were recorded during field visits to the project area, including the forested hillslope above Strawberry Creek and during an Audubon Christmas Bird Count in 2012. One hundred species of birds have been recorded inside the NPS boundary and north of the boundary in the private land pastures and ephemeral ponds that form when the wetland water levels are high, usually during the winter rainy season (Appendix D).

Large mammals known to use the project area include coyotes (*Canis latrans*), black bear (*Ursus americanus*), mountain lions (*Puma concolor*), and black-tailed deer (*Odocoileus hemionus*). Roosevelt elk (*Cervus elaphus roosevelti*) are the most common large mammals in the project area. A resident elk herd consisting of approximately 20 animals uses the pastures around the old SOC, the adjacent wetlands, and the forest above Strawberry Creek. Elk also forage in private pastures adjacent to the project area. In the past, CDFW occasionally issued permits to private landowners to destroy depredating elk. CDFW and the NPS installed an electric fence around the perimeter of the pastures on the east side of the Orick valley and along Hiltons Road to reduce the impact of the elk on livestock forage in the private pastureland.

River otters (*Lontra canadensis*) were frequently seen in the channel downstream following vegetation removal while the channel remained open. Medium-sized carnivores observed in the project area include gray fox (*Urocyon cinereoargenteus*), bobcats (*Lynx rufus*), raccoons (*Procyon lotor*), striped skunks (*Mephitis mephitis*) and spotted skunks (*Spilogale putorius*). A variety of small mammals known, or that are likely, to occupy the project area include shrews (*Sorex bendirei*, *S. pacificus*, *S. trowbridgii*), shrew-moles *(Neurotrichus gibbsii),* bats *(Myotis sp.),* brush rabbits *(Sylvilagus bachmani),* chipmunks (*Tamias sp.*), Douglas squirrels (*Tamiasciurus douglasii*), voles (*Microtus*), deer mice (*Peromyscus maniculatus*), woodrats (*Neotoma*), jumping mice (*Zapus princeps*), murid rats (*Rattus*) and mice (*Mus*), long-tailed weasels (*Mustela frenata*), and short-tailed weasels (*M. erminea*).

Beaver (*Castor canadensis*) moved into Strawberry Creek downstream of the project area in 2012, apparently attracted by saplings recently planted as part of the restoration efforts on private lands. New plantings that were not damaged or killed by the beavers were fenced individually to prevent further damage.

THREATENED AND ENDANGERED SPECIES

Sensitive, Threatened, and Endangered Fish

Anadromous fish rear as juveniles in freshwater, migrate to the ocean to spend their adult life, and return to freshwater to spawn. Two species of anadromous salmonids federally listed as threatened have been observed in Strawberry Creek downstream of the project area: NC steelhead (*Oncorhynchus mykiss*) and SONCC coho (*O. kisutch*). Coho salmon are also listed as threatened under the California Endangered Species Act (CESA). CC Chinook salmon (*O. tshawytscha*) are federally listed as threatened. CC Chinook have not been found in Strawberry Creek but they rear in the Redwood Creek estuary and the South Slough. Strawberry Creek is a tributary to the South Slough.

Coastal cutthroat trout *(O. clarki clarki)* occur in Strawberry Creek downstream of the project area. Strawberry Creek was known historically to long-time residents of the area as a productive cutthroat stream. Coastal cutthroat trout are native to northwestern California, inhabiting most coastal streams north of the Eel River. Cutthroat trout have been taken in samples in the summer in Strawberry Creek, Redwood Creek estuary, and the South Slough. CDFW identifies coastal cutthroat trout as a species of special concern. Previous reviews have determined coastal cutthroat trout do not warrant listing under the federal ESA.

Strawberry Creek contains designated critical habitat for SONCC coho salmon and NC steelhead. The critical habitat unit for these species is all stream and estuarine reaches accessible to the species and includes water, substrate, and the adjacent riparian zone. Accessible reaches are those within their historical range that can still be occupied by any life stage of salmon. Primary constituent elements (PCEs) are those sites and habitat components that support one or more life stages, including freshwater rearing and migration and estuarine areas. Essential elements of critical habitat include adequate (1) substrate, (2) water quality, (3) water quantity, (4) water temperature, (5) water velocity, (6) cover/shelter, (7) food, (8) riparian vegetation, (9) space, (10) safe passage conditions, and (11) salinity conditions. Within the project area critical habitat is compromised due to low dissolved oxygen in reaches accessible to the fish. Most of the reaches within the project area lack cover and shelter and riparian vegetation, and at times exhibit high water temperatures.

Coho salmon and steelhead currently do not occur within the NPS portion of the project area. No coho spawning is thought to occur in Strawberry Creek, due to the poor condition of habitat in Strawberry Creek and its tributaries within the national park. In its present condition, the lower section of Strawberry Creek north of the project area is providing non-natal rearing habitat for coho salmon and steelhead and cutthroat trout. The juvenile fish probably migrated upstream into Strawberry Creek from the South Slough and Redwood Creek estuary, and are able to survive at least in part due to recent stream restoration on private lands downstream of the project area.

Park fisheries biologists have conducted field studies in Strawberry Creek since 1989 to determine which fish species are present. A few salmonids too small to identify as either steelhead or cutthroat trout were captured by electrofishing the tributary above the project area behind SOC in August 1989. The fish were assumed to be cutthroat trout, based on the lack of access for steelhead spawners. Based on their size, park fisheries staff suspected the fish were non-migratory residents. Resident non-migratory fish are localized and maintain small territories, different from the coastal cutthroat population utilizing the Redwood Creek estuary in the summer. The estuary cutthroat trout are saltwater migratory coastal cutthroat that migrate from freshwater streams in late winter and spring to feed in marine environments, including estuaries, during the summer. Electrofishing the same tributary in September 2010 detected threespine stickleback but no salmonids.

To determine fish species that could occur within the project area, park staff have sampled Strawberry Creek downstream of the park boundary from 2008 to the present using baited minnow traps. Additionally, starting in December 2010, NOAA Fisheries staff have sampled Strawberry Creek with minnow traps to complement park sampling. Minnow traps are designed for presence/absence sampling. Initially, sampling locations downstream of the park boundary [listed south (upstream) to north (downstream)], were the wooden bridge in a pasture on private land; Hiltons Road culvert; the Highway 101 bridge; the county waste transfer station at the box culvert; and the confluence of Strawberry Creek and the South Slough of Redwood Creek. In 2009, trapping was begun upstream of the NPS project area immediately above the SOC culvert. In 2012 the site at the confluence of Strawberry Creek location was dropped due to the presence of invasive New Zealand mud snails, and another site added, a beaver dammed stream reach downstream of the county waste transfer station.

Five fish species have been captured in the minnow traps (coho salmon, steelhead, cutthroat trout, threespine stickleback, and prickly sculpin) (RNSP 2009, RNSP unpub. data). Coho were captured at the Hiltons Road culvert, and at downstream sampling locations in 2008, 2009, 2011, 2012, and 2013. In 2013, a coho was captured at the wooden bridge location upstream of the Hiltons Road culvert. Steelhead were captured at sampling sites downstream of project in 2009, 2010, 2011, 2012, and 2013, the upper most presence at the wooden bridge location in 2010. Presence of both species varied among the sites among years; both species were not captured during every sampling event. Cutthroat trout were captured at the Hilton Road culvert and below sites.

No salmonid fish were captured at the trap site above the SOC Road culvert since trapping began in 2008. Dissolved oxygen at this site was 10.3 mg/l in May 2012 and 9.4 mg/l in September 2012. At the wooden bridge site north of the park boundary, dissolved oxygen had dropped to 3.6 mg/l in May and 6.3 mg/l in September. Dissolved oxygen at the Hiltons Road culvert was 5.3 mg/l in September. Salmonids generally require dissolved oxygen above 7.75 mg/l although they can survive at 5 mg/l. Dissolved oxygen less than 2 mg/l is considered lethal to juvenile fish (Water Quality Assessments 1996).

Sensitive, Threatened, and Endangered Wildlife

Three bird and one mammal species considered sensitive are known to occupy, occur adjacent to, or have potentially suitable habitat in, the project area. The marbled murrelet

(*Brachyrhamphus marmoratus*) and the bald eagle (*Haliaeetus leucocephalus*) are known to occur in, or adjacent to, the project area. The project area contains potentially suitable habitat for northern spotted owls (*Strix occidentalis caurina*) and the fisher *(Martes pennanti).* The project area does not contain any designated critical habitat for any terrestrial wildlife species. Detailed species accounts, habitat status, and literature summaries for the three bird species and the fisher may be found in *Threatened, Endangered, and Candidate Species in Redwood National and State Parks, Biological Assessment Reference Document* (2011) and in the biological assessment on effects to threatened wildlife from this project (NPS 2009).

Marbled murrelets are listed as threatened under the ESA and as endangered under the CESA. Marbled murrelets are seabirds that nest in coastal old growth forest along the west coast of North America. The largest population of marbled murrelets in Oregon and California is found in Redwood National and State Parks. Marbled murrelet nests have been confirmed in lower Redwood Creek. Suitable marbled murrelet nesting habitat consists of old-growth forest containing trees with limbs providing nesting platforms and adequate canopy cover surrounding the nest sites. Residual old growth or "legacy" trees left behind after logging may also provide suitable nesting habitat, although the quality of residual habitat varies depending on the density of residual trees plus density and size of any mature trees beneath or surrounding the residual old growth, and on the proximity of residual clusters to blocks of contiguous old growth forest.

Surveys have not been conducted for the marbled murrelet within the project area, although marbled murrelets have been heard flying from west to east over the ridge behind SOC in early morning hours in past years. Habitat for this species on the upper forested hillslope is marginal, with a few large residual trees capable of supporting marbled murrelet nests surrounded by mature second growth conifers. The exact number of ac of residual old growth habitat (in the form of single residuals or low density clusters) in the project area is unknown, due to incomplete mapping. Based on visual observations, the project area contains an estimated 1 to 2 ac of suitable marbled murrelet habitat.

The bald eagle was removed from the federal list of species protected by the ESA in July 2007. However, the federal Bald and Golden Eagle Protection Act of 1940 (16 USC 668-668c) provides full protection almost equal to those protections formerly afforded by the ESA. Bald eagles are listed as endangered under the CESA. There is a known bald eagle territory near the top of the ridge just east of the project area. This territory has been occupied for many years and the pair has produced numerous fledglings. The nest has blown down at least once but has been rebuilt each time very close to the former site.

Northern spotted owls, federally listed as threatened, are forest-dwelling birds that have nested in both old growth and older second growth forests in RNSP. Suitable northern spotted owl nesting, roosting, and foraging habitat consists of dense open-canopied forest stands, with associated large snags and large down logs. The project area contains approximately 600 ac of suitable spotted owl habitat that is of fairly low quality for nesting and roosting, but could be used as foraging habitat. The second growth stands have regenerated primarily as spruce and alder, in size classes that would not provide nesting opportunities. There are a few residual old growth redwood and spruce trees scattered over the hillslope that could be suitable nest trees, although in most cases these are isolated with crowns that are well above the surrounding second growth. Surveys of suitable habitat in the vicinity of the project area have not detected spotted owls in recent years. There are no current surveys of the project area so it is assumed the possibility exists that the area could be occupied by one or more spotted owls. A barred owl territory is suspected to occur near the ridge above Strawberry Creek. The presence of a barred owl territory decreases the likelihood that spotted owls are present in the project area.

The Pacific fisher, a medium-sized forest carnivore in the weasel family (Mustelidae), is a federal candidate for listing as threatened or endangered under the ESA. Potentially suitable fisher (*Martes pennanti*) denning and resting habitat occurs within the project area. The fisher has not been recorded in the project area, although there is a record of a fisher just west of the project area and fishers are expected to occur within the forested hillslope above Strawberry Creek. Similar to the spotted owl, suitable fisher denning, resting, and foraging habitat consists of dense open-canopied forest stands, with associated large snags and large down logs. Approximately 300 ac of potentially suitable fisher habitat occur in the project area.

A small amount (2.2 ac) of suitable spotted owl and fisher habitat may be degraded by removal of stream crossings and a haul road in the forested portion of the project area. No suitable habitat for the marbled murrelet would be removed or degraded by project activities. It is expected that the trees planted along the riparian corridor under either action alternative would provide additional habitat for fisher prey species, along with additional overhead cover preferred by the fisher, thus, improving the habitat for this species within the project area.

Project-generated noise from heavy equipment and/or chainsaw use has been identified as a source of disturbance and a potential threat to the listed species identified in this document during their respective breeding seasons (January 1–September 15). If an adult is disturbed by a sudden loud noise and leaves a nest or den site, the unprotected young are at an increased risk of predation. For this reason, restriction periods have been established by the USFWS to protect listed species from noise disturbance during the nesting season. During noise restriction periods, no activity that creates noise in excess of ambient noise is permitted. Specifically, 0.25-mile no-entry buffers would be applied to work around stream crossings in proximity to residual old growth trees in the hillslope portion of the project area to protect nesting marbled murrelet. The marbled murrelet restriction period is March 24–September 15.

CULTURAL RESOURCES

Cultural resources are defined as archeological resources, prehistoric or historic structures, cultural landscapes, and traditional cultural properties. These resources are called “Historic Properties” when they are either listed in or are determined eligible for listing on the National Register of Historic Places under Section 106 of the National Historic Preservation Act (36 CFR 800, *Protection of Historic Properties*). Criteria for determining eligibility of listing such resources on the National Register include the following:

> The quality of significance in American history, architecture, archaeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, association, and that are associated with A) events that have made a significant contribution to the broad patterns of our history; or B) that are associated with the lives of persons significant in our past; or C) that embody the distinctive characteristics of type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or D) that have yielded, or may be likely to yield, information important in prehistory or history.

Cultural resources can be sites, objects, structures, places, landscapes, or natural elements of places or landscapes. Cultural resources in Redwood National Park include archeological sites, historic structures, ethnographic resources, cultural landscapes, and museum objects, as defined in NPS Director's Order 28.

Through the identification methods under 36 CFR 800.4, the NPS identified a 20-acre Area of Potential Effect (APE) for the proposed action. In accordance with 36 CFR 800.16(d), the APE was based on a detailed summary of the APE and the approximate three-dimensional characteristics of ground disturbance associated with each engineered component of the project (Grantham and Short 2013).

In accordance with 36 CFR 800.4 measures taken by NPS to identify historic properties in the APE included the following: background research and literature review; surface archeological survey of the entire APE project area; a historic evaluation of SOC, a former dairy that was later used by NPS as an administrative facility; and consultations with the Yurok Tribe and its culture committee.

Most of these identification methods are summarized in a confidential report (Cooper, Roscoe, and Van Kirk 2010) prepared for NPS by the Humboldt State University Cultural Resources Facility (HSU CRF). A letter report addendum to the 2010 report dated November 19, 2013 was prepared to address the changes to the APE from revisions to the project made in the final design submittal (Love and Shea 2012), but it did not result in any new findings differing from the original 2010 investigations.

Through these studies, the NPS identified three possible cultural resources—the historic period Antonioli Ranch and two log stringer bridges. None of these resources was recommended as eligible for listing in the National Register of Historic Places (Cooper, Roscoe, and Van Kirk 2010).

General Prehistoric and Historic Context

Documented human occupation or use of land under Redwood National Park jurisdiction and vicinity date to as early as 5,000 to 7,000 years ago (Benson 1983, Tushingham et al. 2008). Evidence of prehistoric human activities include village sites, seasonal camps, and trail use sites reflected in the archeological record by artifact concentrations and associated features found in the Bald Hills prairies, along the coast, and in some instances within forested areas in the Redwood Creek basin and other perennial drainages. Historic-period activities on park lands included exploration, cattle and sheep ranching, dairies, farming, logging, mining, establishment of overland transportation routes, and World War II and cold war era military history.

American Indians have lived in the area continuously for thousands of years. They live in local communities, reservations, or rancherias around the parks, and continue to practice traditional lifeways. Lands that are now part of RNSP are within aboriginal Tolowa, Yurok, and Chilula territory. Tolowa territory extended north along the coast from Wilson Creek and included most of the Smith River watershed in the interior. Yurok territory bordered the Tolowa to the south and extended from Damnation Creek in the north to the Little River along the coast, and included the lower 45 miles of the Klamath River watershed. Chilula territory included most of the lower Redwood Creek drainage and included the Bald Hills area (Eidsness 1988). The project area includes Yurok and Chilula ancestral lands.

The Klamath River Reservation was established along the lower portion of the river in 1855 through a presidential executive order. In the late 1860s and 1870s, a number of Americans took up residency on the reservation but were evicted in 1879. In 1891, President Harrison enlarged the nearby Hoopa Valley Indian Reservation to include lands along the Klamath River one mile on either side of the river from just upriver of Weitchpec to the Pacific Ocean, thus encompassing the original Klamath River Reservation. In 1892, Congress opened the reservation to homesteading by non-Indians and awarded allotments to Indians living along the river. Because of the homesteading, the majority of lands along the Klamath River within reservation boundaries are owned by non-Indians. The Hoopa-Yurok Settlement Act of 1989 divided the Hoopa Valley Indian Reservation into the Yurok and Hoopa Valley reservations. The Yurok and Hoopa Valley tribes are currently amending the Act to establish jurisdiction for lands and resources, and to provide the legal background for appropriation of funds, management of lands and resources, and development of infrastructure and economic opportunities for the Yurok Tribe.

Following severe flooding along the Klamath River in the winter of 1861-62, the reservation was essentially abandoned. A new reservation site was selected north of Crescent City. Numerous Tolowa were concentrated here, along with members of tribes from the Mad and Eel Rivers south of aboriginal Yurok territory.

The NPS has held regular consultations with the American Indian community since 1978, initially with five American Indian heritage advisory committees representing different geographic areas of the parks and different Indian groups. In the 1990s, consultations shifted from heritage advisory committees to tribal governments. Currently, there are five tribal governments whose members have ties to lands within the project area and the vicinity. These governments include the Yurok Tribe of the Yurok Reservation, California; Coast Indian Community of Yurok Indians of the Resighini Rancheria, California; Big Lagoon Rancheria of California; and Cher-Ae Heights Indian Community of the Trinidad Rancheria, California; and the Hoopa Valley Tribe of the Hoopa Valley Reservation, California.

The first Euro-Americans in the area that is now Redwood National Park were engaged in exploration, fur-trading, mining, and packing and freighting of supplies for mining camps along the interior rivers. Settlements were established along the coast, attracting farmers and ranchers who settled along the pack trails and coastal bottomlands. Other settlers farmed and raised cattle in the Bald Hills area and provided amenities for teamsters stopping en route to the interior mines.

Archeological Resources

Archeological resources “are the remains of past human activity and records documenting the scientific analysis of these remains.” As of September 2009, a total of 112 archeological sites are documented in the national park. These include prehistoric village sites, seasonal camps, procurement sites, and trail use sites. Historic period archeological sites include structures and associated features related to ranching and farming, and historic-period trash scatters related to settlement, logging, and mining, as well as various ranching landscape features such as fence lines and stock ponds.

In the Strawberry Creek project area, a geotechnical study conducted for the project in combination with a soil investigation and soil survey data indicates that soils and sediment deposits in the area are Holocene in age, which according to a recent Caltrans study would indicate that the lower Redwood Creek valley is a location where buried archeological deposits could be found. The possibility of finding buried archeological deposits at this specific location is exceedingly low for the following reasons:

- A comprehensive surface survey was conducted which resulted in negative findings for archeological resources.
- Comprehensive background research and literature reviews were conducted that resulted in negative findings for significant historic properties in the APE.
- Multiple consultations with the Yurok Tribe and its culture committee were conducted that did not indicate an awareness of any significant traditional cultural resources in the project area that would be uncovered or disturbed by excavations.
- Soils are composed of stratified layers of gravelly sand to silty clay and include numerous layers of peat, which suggest frequent flooding associated with Redwood Creek, and wetland or riparian plants communities that were significantly impacted and buried during flooding events. The APE is located in an active floodplain, and based on soils data, has been an open water channel-wetland complex for a significant portion of the Holocene.

- The prehistoric floodplain was a mosaic of open water channels, riparian forest, adjacent wetland depressions with sedges, grasses and hummocks with Sitka spruce and redwood as the dominate forest species.
- No buried cultural deposits were encountered during soil and sediment coring investigations.
- Soil and geological characteristics of the APE indicate the area would not have been conducive to human occupation for any length of time, and negative findings for cultural resources support this.

Historic Structures

Structures "are material assemblies that extend the limits of human capacity," and comprise such diverse objects as buildings, bridges, vehicles, monuments, vessels, fences, and canals.

In the project area, the former William Antonioli Ranch, which later became the South Operations Center of Redwood National Park, was constructed sometime between 1948 and 1954. Today it consists of a house, barn, garage, sausage house, tool shed, and hose house. The NPS determined the ranch and two log stringer bridges were identified in the project area, but for the purposes of this project were found to be ineligible for listing in the National Register of Historic Places.

Ethnographic Resources

Ethnographic resources "are basic expressions of human culture and the basis for continuity of cultural systems" and encompass both the tangible (native languages, subsistence activities) and intangible (oral traditions, religious beliefs). These can include archeological sites, old ethnographic village sites, travel routes, fishing and hunting camps, locations of ceremonial significance, and areas traditionally used to gather resources.

Principal settlements for Yurok and Chilula were typically situated along the coast and rivers or creeks. Village sites, many now recorded as archeological sites are found throughout these areas. Villages were often located in clusters with the population centered around a large village with smaller villages or hamlets in the vicinity. These locations were occupied by the bulk of the population throughout the year with temporary campsites near specific resources used seasonally by small groups to exploit seasonally available resources.

Among the local Yurok, Tolowa, and Hupa, many aspects of the traditional lifeways continue on both park and adjacent lands. The parks contain sites that are integral to the practice of traditional American Indian spirituality, subsistence, and lifeways. Some fishing areas, gathering areas, and ceremonial sites now within Redwood National and State Parks have been used by the American Indian community for thousands of years. Certain dances are held, and others are being revived that entail the maintenance of dance sites with their traditional structures and the fabrication of dance regalia. Many of the arts such as canoe making and basket weaving also are practiced, which require certain natural resources, many of which are found within the parks. These arts are sources of economic as well as spiritual sustenance.

Strawberry Creek is located in the ancestral land of the Yurok people, who ascribe significance to all of the area’s natural and cultural resources including but not limited to Strawberry Creek and its entire ecosystem. The Yurok THPO and the Yurok Tribe’s culture committee have indicated that restoration of Strawberry Creek is consistent with Yurok values.

Cultural Landscapes

Cultural landscapes are “settings we have created in the natural world.” They are intertwined patterns of natural and constructed features that represent human manipulation and adaptation of the land.

No cultural landscapes were identified in the project area.

National Register of Historic Places

No NRHP eligible properties were found in the Strawberry Creek project area.

VISITOR USE AND EXPERIENCE

Visitors have been observed in the project area viewing wildlife, mostly birds, along the SOC Road. Visitor use is very limited because the project area is behind a locked gate and is not signed or advertised as a visitor use area in park informational media. There are no visitor facilities in the project area. The nearest visitor facilities are the Kuchel Visitor Center and Redwood Creek Picnic Area located south of the mouth of Redwood Creek at the northern end of Freshwater Lagoon Spit. Informal visitor use such as bird-watching occasionally occurs along Hiltons Road.

NATIONAL PARK SERVICE OPERATIONS IN THE PROJECT AREA

The NPS acquired the former Antonioli property in the 1978 park expansion and began construction of park administrative facilities in 1983. From 1984 to 2003, the project area served park administrative functions as the original South Operations Center, which housed offices and facilities for resource management, law enforcement, and maintenance functions. In 2003, these functions were relocated to a new facility in the town of Orick. Boundary fencing to prevent livestock trespass onto the park from private land downstream of the project area was installed in 1985. This fence will remain. A park residence constructed in 1990 will remain in the project area along with storage area for supplies and materials used for maintenance and resource management activities. Informal visitor use occurs in the project area. Park resource management staff lead field trips to the project area to discuss stream restoration in the context of stream functions that have been altered by past land uses.

SOCIOECONOMIC ENVIRONMENT

Private lands in the Orick valley in the vicinity of the project area have been historically and are actively used for livestock grazing and hay production. Prior to the 1978 park expansion, the hillslopes surrounding the project area were used for timber production. Residential and commercial developments in Orick are concentrated along U.S. Highway 101. Less dense residential developments occur on Hiltons Road on the edge of the project area.

ENVIRONMENTAL CONSEQUENCES

This section describes the anticipated effects of the alternatives on natural and cultural resources, park operations, and socioeconomic effects. Methodology for assessing impacts on cultural resources and additional definitions are found under *Impacts on Cultural Resources*.

IMPACT DEFINITIONS

Impacts are analyzed according to the type of impact (beneficial or adverse), the timing and duration of impact (short-term, long-term, one-time, occasional, repeated) and the severity or intensity of impact (no effect, negligible, minor, moderate, or major). These factors are also considered in the context of the geographic location of the park and the region.

Type—The type of impact describes whether an action would benefit or harm a resource. A beneficial effect improves the condition of a resource, protects it from damage or loss, or favors the persistence of a resource. A harmful or adverse effect is one that worsens the condition of a resource, damages or degrades a resource, leads to the loss of the resource, alters it irretrievably in an undesirable way or changes its essential character so that the resource no longer possesses integrity or its defining characteristic. Adverse effects are unfavorable to the conservation and preservation of the resource.

Timing and Duration— The timing of an impact is also part of its context. For example, removing brush and trees in October does not affect nesting migratory birds but brushing the same area in June would affect birds nesting in the vegetation. Ground-disturbance during the rainy season could cause run-off into a stream channel.

The duration of an impact considers whether an effect would happen immediately, the length of time over which an impact occurs, and how long it would be noticeable. Duration is defined as short-term or long-term, although the duration of an effect is related to the resource affected. In general, long-term effects would be those that are repeated over at least several years or that would not be immediately noticeable.

Short-term effects on annual vegetation would generally be on the order of a year or less, because a year includes one complete growing season. In the context of resources such as soils or plant communities, or for long-lived plants such as Sitka spruce or redwood trees, or for geological processes such as flooding, long-term refers to effects on the order of decades to centuries.

Intensity— The intensity of impacts can be summarized as follows.

- No effect: No impacts, or impacts are not detectable.
- Negligible: The impact is barely detectable.
- Minor: The impact is slight, but detectable.

- Moderate: The impact is readily apparent.
- Major: The impact is severely adverse or beneficial.

Intensity of effects on hydrology and floodplains associated with different flow levels are based on the following definitions:

- Negligible=no change from existing conditions (less than 2 year flow event)
- Minor=change associated with the 2-10 year flow
- Moderate=change associated with the 10-25 year flow
- Major=changes associated with a 25 year and greater flow event

Intensity or degree refers to how much of an effect an action has on a resource and is described as negligible, minor, moderate, or major. Major effects are considered significant. Determining intensity relies on understanding the range of natural variation of a resource. Actions are more likely to result in a gradient of change rather than a distinct level of change, so that some effects may be judged "minor to moderate" to indicate that portions of a resource in different locations might be affected slightly differently by the same action. For natural resources that are distributed discontinuously across a landscape or where individual elements of a resource are not exactly equivalent to other individuals or pieces of the same resource, a range of effects from a single action is likely.

If an action has no effect on a resource, or if the effect is barely noticeable or measurable, the effect is considered negligible. Negligible effects are those that are unnoticeable, undetectable, or result in no change to a resource, or that affect so few individuals that the effect cannot be distinguished from the natural variability for a resource. Significant effects are always noticeable and result in a permanent change to a resource over a large area.

Levels of change between negligible and significant are described as minor or moderate. Minor changes to a resource are detectable and generally noticeable but there is no long-term or permanent alteration of the resource and the changes are within the range of natural variability. Minor effects result in only a slight change to a resource or occur in a small area, and do not change its function.

Moderate effects are always noticeable, and result in some change to the resource or its function, and occur in several areas. If an action changes the resource completely or a change is irreversible, the effect is considered significant or major.

The intensity of an impact also includes consideration of how widespread or local the area of impact would be, the amount of a resource that might be affected, or the number of times an effect would occur. If an action affects all of a resource within the parks, that impact would be considered major or significant.

Intensity of effects on non-listed plants and animals is based on the number of individuals affected in relation to the total population in the project area, the park, the region, and the range of the species. If only a few individuals of a plant or animal are affected, the impact would be considered negligible. If an action affects more than a few individuals but the effects are within the natural level of variability for a population or a resource, the effect is considered minor. If an action affects many or all individuals and causes changes to populations that are greater than the natural level of variability, the effect is considered moderate.

For sensitive wildlife and plants, there are two sets of definitions for intensity. One set of definitions is used in this EA based on the NEPA regulations (40 CFR 1500, *et seq.)* and the NPS guidelines for implementing NEPA. The USFWS and NMFS use a second set of definitions to accompany determinations of effect based on regulations for implementing the ESA. Negligible effects on listed species for the purpose of this EA are defined as those that are unnoticeable or that the USFWS or NMFS have determined to have “no effect.” The USFWS and NMFS define a “no effect” determination as the “appropriate conclusion when the action agency determines its proposed action will not affect listed species or critical habitat.” USFWS and NMFS define impacts that result in a determination of “may affect but not likely to adversely affect” as “discountable or insignificant”; these effects are defined in this EA as minor. Adverse effects occur if impacts are not discountable, insignificant or beneficial. Impacts that are determined to be adverse but can be lessened or minimized, even though incidental take may still result, are considered moderate. An effect that is determined by USFWS or NMFS to result in jeopardy to a listed species is defined as major or significant.

Context—The context of a park action includes consideration of the effects on resources in the project area, and on similar resources within the parks, the local area surrounding the parks, and the region.

The geographic context of an impact includes consideration of the project area, the parks as a whole, and local and regional conditions.

METHODOLOGY FOR ASSESSING IMPACTS ON NATURAL RESOURCES

Impacts were assessed using several methods, including best professional judgment and knowledge of the effects of similar actions undertaken by the NPS in Redwood National Park and other NPS units, and from the analyses in the planning reports and design memoranda prepared by Love and Associates (2008) and Love and Shea (2010, 2011, 2012). The planning report and design memoranda were prepared by engineers licensed in California and their subcontractors. Impacts are also based on comments from review and revision of designs by geologists, hydrologists, wildlife and fish biologists, botanists, and soil scientists from NPS, CDFW, USFWS, and NMFS.

Impacts to vegetation, wildlife, and threatened and endangered species were assessed through site visits and discussions among NPS botanists and biologists.

Impacts on threatened and endangered species were assessed in consultation with USFWS and NMFS personnel, and review of the biological opinions or letters of concurrence issued by these agencies through informal and formal consultations under Section 7 of the federal Endangered Species Act.

Impacts on water quality, hydrology, and geomorphology were determined through on-site analyses by park geologists and engineers who prepared the designs under contract. Impacts to floodplains at different flow levels are based on the thresholds found in the 1999 RNSP GMP/GP FEIS/R. Impacts from predicted sea-level rise are based on recent publications (Pacific Institute 2009a,b; National Academies of Science 2014).

The area of wetlands affected are estimates based on calculations and GIS analyses of the engineering drawings and design reports (Love and Shea 2010, 2011, 2012). Methodology for assessing wetland conditions used the California Rapid Assessment Method (CRAM) to compare and predict changes in wetland functions before and after project implementation (CWMW 2009, 2012).

Impact analyses on water quality, fish, and aquatic habitat from restoration activities in the project area are derived from the impacts described in the NOAA RC Biological Opinion and Essential Fish Habitat consultation and from the informal consultations and/or biological assessments prepared by the NPS biologists and submitted to USFWS and NOAA Fisheries under procedures for consultation in compliance with Section 7 of the ESA (Schmidt and Bensen 2009; NMFS 2010, 2012; NPS 2011b, c).

For the purpose of consultation with the USFWS and NMFS, potential impacts on threatened and endangered species were defined as no effect; may affect but not likely to adversely affect; may affect and likely to adversely affect; and beneficial effect.

EFFECTS ON CLIMATE AND AIR QUALITY

None of the alternatives would have effects that could contribute substantially to climate change. The largest source of GHG in RNSP is emissions from mobile combustion (vehicles burning fossil fuels) (RNSP 2011). GHG emissions from equipment associated with maintenance of Hilton Road under all alternatives would remain at current levels. Construction equipment used under either action alternative would temporarily increase GHG emissions. The conversion of up to 0.9 acre of Palustrine Emergent wetland to riparian upland under either of the action alternatives would have negligible effects on storage of carbon in the wetland soils (soil carbon); the remaining 30 ac of Palustrine Emergent wetland surrounding the proposed stream restoration project would continue to store carbon in the undisturbed wetland soils.

Under all alternatives, including no-action and the proposed action, predicted sea level rise of 1.4 meters (55 inches) by the year 2100 due to global climate change would not appreciably increase the hazard from a large CSZ tsunami event. Predicted sea level rise of 1.4 meters (55 inches) by the year 2100 would slightly increase the predicted tsunami run-up in the project area from a major Cascadia event (Pacific Institute 2009a). Most of the project area is already within the predicted tsunami hazard zone for current sea level.

No-action Alternative

Under the no-action alternative (Alternative 1), there would be no effects on air quality from emissions from construction equipment. There would be short-term localized decreases in air quality from emissions from heavy equipment and dust generated by annual routine maintenance (grading) of the gravel road to SOC and the ranger residence; this adverse effect on air quality would be negligible.

Action Alternatives

Under both action alternatives, there would be short-term localized decreases in air quality from emissions from heavy equipment and dust generated by annual routine maintenance (grading) of the gravel road to SOC and the ranger residence, and from heavy equipment used for excavation of old culverts, road segments, and stream channel.

Heavy equipment would be licensed under state requirements to control emissions. No dust would be generated from restoration actions in the downslope project areas because the soils that would be disturbed are damp. There would be short-term localized decreases in air quality from dust generated from the upslope watershed restoration treatments to excavate stream crossings and replace culverts on SOC Road. These adverse effects on air quality would be short-term, localized, and negligible.

Cumulative Effects on Climate and Air Quality

Cumulative effects on air quality in the project area result from dust from soil disturbance and emissions from vehicles and power tools associated with maintenance of park roads and trails; management of second growth forest from re-occupation of logging roads and landings; fire management including preparation of roads and firelines for prescribed fires and wildfires and smoke from prescribed fires and wildfire suppression; timber harvest on adjacent private lands; vehicle emissions from public roads and highways; and smoke from wood stoves in adjacent communities. Smoke from prescribed fires and wildfires has the greatest potential for moderate adverse effects but smoke is temporary for the duration of the fire and generally occurs in the late summer or early fall. These effects are adverse, localized to widespread, temporary but repeated, and negligible to moderate. No long-term cumulative adverse effects on air quality or air quality related values in the parks are anticipated for the foreseeable future because the regional prevailing winds are from the northwest across the Pacific Ocean where there are no significant sources of air pollution. The cumulative effects on air quality under either action alternative would be negligible, because the primary sources of air pollution in the project area are vehicle emissions and smoke from wood stoves or residential burn piles, and state air quality standards in the project area are rarely violated by either source.

Conclusions: Effects on Climate and Air Quality

None of the actions, including no-action and the proposed action, are anticipated to cause long-term increases in GHG emissions that contribute to climate change. None of the actions, including no- action and the proposed action, are anticipated to have long-term adverse effects on air quality or air quality related values. Effects on air quality under all alternatives would be localized and temporary, primarily from dust from road-grading for routine maintenance of SOC Road under all alternatives. Adverse effects under both action alternatives would be slightly greater from construction activities and equipment emissions. Adverse effects on air quality would therefore be negligible.

EFFECTS ON SOILS AND TOPOGRAPHY

No-action Alternative

Under the no-action alternative, there would be no additional changes to topography in the project area from construction activities. The upslope areas have been altered by road construction associated with logging. The wetland complex has been ditched for drainage and aggraded by sedimentation from upslope activities and by invasive grasses that filled in the stream channel. The road fill and soils adjacent to the four stream crossings would continue to gradually erode in rain storms. Major storms would potentially cause major slope failure. Eventually, the crossings would fail completely, delivering an estimated 630 cu yd of road fill into the wetland area and Strawberry Creek downstream of the project area.

The administrative area, including the ranger residence that will remain, is located on an alluvial fan formed by the SOC Tributary. The tributary reach on the alluvial fan has been moved and levied, but would continue to aggrade as sediment from upslope sources moves down to the valley floor. Aggradation would contribute to the likelihood that the channel would avulse over the long-term. (Avulsion is the abandonment of a stream channel and formation of a new channel, a tendency of deltaic channels.)

Action Alternatives

Stream Crossing Removal— Under both action alternatives, an estimated 1,600 cu yd of soil over a total area of about 19,200 sq ft (0.44 ac) would be excavated to remove the four stream crossings. The four channel excavations range from 3-7 feet in width and 75-100 feet in length. Excavation at one of the four sites is estimated to be about 23 feet in depth at one place; excavation at the other three sites would be shallower. These soils were previously disturbed by timber harvest and associated road construction but have begun to recover in the 40-50 years since the original disturbance. Approximately 1000 cu yd of excavated road fill would be hauled to SOC until it can be used for construction of the planning mounds. The remainder would be moved to stable locations as close as possible to the work sites and placed where it would not erode into stream channels. Freshly exposed soils would be covered with straw or mulch obtained by grubbing vegetation from the excavation areas on the slopes and adjacent to the stream crossing. Excavation of the crossings would prevent an estimated 630 cu yd sediment from being delivered into Strawberry Creek. During the first rainy season following excavation, an estimated maximum 24 cu yd of soil could erode as the newly excavated channels adjust. The stream channels are generally filled with wood debris from past logging disturbances. The presence of wood debris and the long lengths of channel between the upslope stream crossing excavation sites and the downslope restoration area are expected to attenuate sediment delivery to the restored stream segments.

Channel Realignment, Instream Structures, and Planting Mounds— Under both action alternatives, soils would be affected by excavating channels filled in with sediment and/or reed canary grass; realigning the stream channels for the SOC Tributary, main channel of Strawberry Creek, and West Tributary; and creating planting mounds adjacent to the newly realigned channels to simulate hummocks associated with the original Sitka spruce forest described in historical accounts.

Under Alternative 2 (proposed action), approximately 11,830 cu yd of materials would be used to create planting mounds. The mound material includes about 1,050 cu yd of material excavated from the channel restoration activities; gravel imported from the Redwood Creek levee maintenance project (approximately 7,310 cu yd); fill/spoil material from a highway spoil site within the park (2,470 cu yd); and 1,000 cu yd from the upslope road/stream restoration area. If these materials are insufficient or do not meet the engineering specifications to create stable mound structures, additional material would be purchased from some other commercially-available source.

Under Alternative 3**,** approximately 5,470 cu yd of excavated material from the channel restoration portion of the project would be used to create planting mounds within the wetland area. Additional materials would be obtained from the sources identified under Alternative 2 above.

Under both action alternatives, the topography would be altered to create the designed grades of the stream channels and stream profiles to approximate the reference reach in the upper reaches and to provide for passage of all life stages of fish in the new stream channels. Instream structures would alter channel bed morphology by providing pools and drops. The topography of the wetland complex would be altered to create the planting mounds. The tops of the planting mounds would be approximately 24 feet elevation, which is about 4.5 feet above the dry season water surface elevation of 19.5 feet and about 3 feet above the average wet season water level elevation of 21 feet.

Culvert Replacement(s)— Under Alternative 2 (proposed action), replacement of the West Tributary culvert would affect about 340 cu yd of soils for excavation of the old culvert and installation of a new culvert.

Under Alternative 3, replacement of the West Tributary culvert would affect about 282 cu yd of soils.

Under Alternative 3 only, replacement of the SOC Tributary culvert would affect about 277 cu yd of soils. The gradual slope transition in the channel profile after installation of the new SOC Tributary culvert would eliminate the abrupt discontinuity in sediment transport that presently occurs at the culvert. The improved sediment transport conditions should maintain an open stream channel for fish passage and minimize channel avulsions.

If needed to maintain 18 inches of cover over the new SOC Tributary culvert, the road would be raised up to six inches along a 20-foot length, which would require 1,380 square feet of fill to be placed over the new culvert. This material would be purchased from a commercial source.

Cumulative Effects on Soils and Topography

Strawberry Creek enters the South Slough of Redwood Creek in the reach of the estuary confined within the flood control levees. Under both action alternatives, removal of the four stream crossing in the upper reaches of Strawberry Creek would have no effect on topography and soils in other sub-basins in the Redwood Creek watershed. Topography in the other sub-basins of Redwood Creek would remain altered by presence of logging roads. Soils would continue to erode in unstable areas and along unmaintained roads in the Redwood Creek watershed. Major winter storms would potentially alter topography in the watershed upstream of the project area through landslides related to untreated roads.

Around 1,400 miles of forest roads and over 5,000 miles of skid trails are estimated to have been built within the Redwood Creek watershed. About 445 miles of roads and 3,000 miles of skid trails were included within the national park boundary. Over the very long-term, as failing roads within the park are removed; upstream roads outside the park are maintained; and effective erosion control on all roads implemented, there would be a major benefit to soils and topography in the Redwood Creek watershed from preventing unnaturally high levels of erosion. The long-term effect on the Redwood Creek estuary from reducing sediment input from upstream sources would be a moderate benefit to estuary function because the Redwood Creek levees would continue to alter the hydrology and function of the estuary. Under both action alternatives, removal of four stream crossings would save an estimated 630 cu yd of soil from entering the Redwood Creek estuary but this benefit would be negligible compared to upstream sediment input into the estuary.

Projects implemented downstream of the project area as part of the overall restoration recommended in the Lower Strawberry Creek Restoration Planning Report (RCWG 2006) would not affect soils or topography in the project area.. These projects include repeated removal of reed canary grass along 0.6 mi of the main Strawberry Creek channel from U.S. Highway 101 upstream to the park boundary, re-plantings of native trees and shrubs to inhibit the regrowth of the canary grass, and replacement of a culvert at the Humboldt County Waste Transfer Station with a “fish-friendly” culvert that allows passage for all life stages of salmonids is scheduled for implementation in summer 2014.

Additional topsoil and gravel needed to create planting mounds would be purchased from commercial sources that are permitted under current California regulations. Extraction of these materials would not have direct adverse effects on park resources within the project area.

Conclusions: Effects on Soils and Topography

Under both action alternatives, soils within the project area would be affected by excavation for removal of four stream crossings, culvert replacement[s], channel realignment, instream structure installation, and creation of planting mounds. Restoration projects on Strawberry Creek downstream of the NPS project area (removal of reed canary grass, replanting of native trees and shrubs, and replacement of the culvert at the Humboldt County Waste Transfer Station) would not affect soils or topography in the project area. For the projects downstream of the NPS project area, construction–related effects on soils and topography to clear out the stream channel, replant riparian areas, and replace the culvert would have short-term effects on soils. These soils are previously disturbed by alterations to the creek, installation of the original culvert, and agricultural activities. Both the short-term and long-term benefits and adverse effects to topography from these restoration actions are negligible. The short-term and long-term effects to soils from excavation are considered minor because of the limited area affected in relation to the extent of soils with similar qualities in the project vicinity that would not be affected by the restoration actions.

Removal of the four stream crossings under both action alternatives would have a negligible benefit to the Redwood Creek estuary from reduction of an estimated 630 cubic yards of sediment under both action alternatives, and no effect on topography of the estuary which is highly altered by flood control levees and levee maintenance activities.

Under the proposed action (Alternative 2), excavation of 1,064 cu yd of soil for channel excavation, replacement of the West Tributary culvert, and West Tributary channel would have long-term effects on soils. Mound creation would require placement of 11,830 cu yd of which would affect underlying soils. Under Alternative 3, about 5,470 cu yd of soil would be excavated to create channel and mounds, and to replace the culverts on SOC Road at the West Tributary and the SOC Tributary.

Some of the material from the wetland area excavation and from the upslope restoration sites would be re-used to create mounds under both alternatives, with additional material imported from sources within or near the park as needed. Under the proposed action (Alternative 2) approximately 1,050 cu yd and approximately 5,470 cu yd under Alternative 3 of material excavated to create channels would be used to create planting mounds along restored stream channels.

Effects on soils from excavation to create new stream channels are adverse and long-term but judged to be minor and unavoidable because the excavation is required to meet the purpose and need for the project. About 30 ac of soils with properties similar to the excavated soils would be undisturbed in the wetland outside the limits of disturbance for the project, as well as on adjacent private lands in the project vicinity.

Under the proposed action (Alternative 2) approximately 340 cu yd of soils would be excavated to replace the West Tributary culvert. Under Alternative 3, approximately 282 cu yd and 277 cu yd of soils would be excavated to replace the West Tributary and SOC Tributary culvert, respectively. Adverse effects on soils from excavation for culvert replacement under both alternatives would be negligible because the affected soils are road fill that is regularly graded, occasionally regraveled, and otherwise maintained for vehicle use as an NPS administrative road.

Under both action alternatives, the short-term effects from excavation of soils to create channels and placement of borrow to create mounds are judged to be minor and adverse. The overall long-term effects on topography in the project area under both action alternatives are judged to be beneficial and negligible for changes to topography and reduction of sediment threat to the Strawberry Creek watershed from removal of four stream crossings; beneficial and minor from realignment of the stream channels and replacement of culvert[s]; and moderate and beneficial to the extent that the alteration of topography and soils from excavation and creation of mounds is needed to meet the purpose and need for stream restoration.

EFFECTS ON HYDROLOGY AND WATER QUALITY

No-action Alternative

Under the no-action alternative, there would be no improvement to hydrology within the project area. The original hydrology of Strawberry Creek has been affected by alterations to the creek for agricultural development. The upslope stream crossings would remain filled in with sediment with no defined channel at the crossing. There would be no free-flowing channel to function as stream habitat and to convey flows downstream. Large storms would continue to inundate the entire wetland.

Two aspects of water quality are addressed in relation to restoration alternatives—turbidity as a measure of erosion and sedimentation, and dissolved oxygen relative to fish survival. Under the no-action alternative, there would be no project-related effects on water quality. Reed canary grass would continue to deplete dissolved oxygen from water in the wetland area during low flow periods. There would be no short-term increases in turbidity from excavation or instream work to restore the stream channels, creation of planting mounds to support riparian vegetation, or replacement of culvert[s] on the SOC Road, or from flushes of disturbed sediment in the first few storm events following soil disturbance.

The upslope stream crossings would continue to degrade as the road fill ages and deteriorates. Gradual failure of the stream crossings would release small quantities of sediment into the wetland area and downstream reaches of Strawberry Creek during storms. Large storms would cause more erosion, and more sediment would enter the wetland and creek. Eventually, the stream crossings would fail completely, which would most likely occur during a major storm. Complete failure of the stream crossings would release an estimated 630 cu yd of road fill which would enter the wetland area and the downstream reaches of Strawberry Creek. On-going maintenance of the SOC Road and drainage system would minimize erosion and run-off from the road into the wetland area from small storms. Complete failure of SOC Road culverts would produce additional run-off of road fill into Strawberry Creek. Erosion and sedimentation from SOC Road and the stream crossings would have adverse effects on water quality in Strawberry Creek.

Under the no-action alternative, dissolved oxygen in the wetland area and existing stream channels would remain extremely low, especially during low summer flows.

Action Alternatives

Channel Restoration and Culvert Replacement— Under both action alternatives, channels have been designed to provide adequate flow conveyance for the bankfull flow and to create open, low velocity channels.

Under both action alternatives, the West Tributary channel profile was designed to restore the channel upstream of the culvert to its historical elevation. The channel cross sections are designed to contain larger flows to reduce the risk of channel avulsion. Downstream of the SOC Road culvert, higher flows would inundate the constructed and existing overbanks surfaces and flow into the dead-end and side channels. Restoration of channel depth and shape would restore a more original hydrological condition of flow.

Under both action alternatives, log and boulder structures placed in the new stream channels would create discrete drops to control the channel bed elevation and create scour pools that dissipate the flow energy.

Using two different types of structures would create variability in drop heights, pool lengths, channel cross section, and overall appearance. Log weirs are intended to maintain channel stability if an upstream log structure fails, with less vertical drop between structures to minimize pool scour depth and reduce the potential for undermining of the structure.

Under both action alternatives, there would be short-term adverse effects on water quality from erosion of sediment during the first few rainy seasons following excavation of 1,600 cu yd of road fill from the four stream crossings upslope of the wetland complex and in the newly excavated channels of Strawberry Creek and the West Tributary until the channels adjust and excess silt is washed downstream. The volume of soil that would be mobilized as the four stream crossings adjust to the new configuration is estimated to be a maximum of about 24 cy yd. The volume mobilized in any given event, the number of storms in which erosion occurs, and the total time needed to erode all of predicted 24 cu yd would depend on the number and intensity of the storm events.

Short-term erosion would be reduced by working during low-flow periods, diverting stream flow around work sites, mulching newly exposed soils, completing instream work prior to the onset of the rainy season, installing silt fences, and using other standard best management practices for erosion control required under the CDFW and NMFS permits for working in streams with habitat for anadromous fish.

Both action alternatives would have temporary adverse effects on water quality from erosion of newly excavated soils, primarily in the first rainy season as small quantities of sediment are flushed from the stream channel. The first flush or pulse of sediment into the system is likely to occur during stormflows immediately following project completion. Fine sediment accumulated within the new channel during construction and along wetted stream perimeters would be mobilized by stormflows following construction and flushed downstream. The volume of soil that would be mobilized as the four stream crossings adjust to the new configuration is estimated to be a maximum of about 24 cubic yards. Based on park monitoring data collected in Prairie Creek downstream of park road watershed restoration projects in Lost Man Creek over the past decade, it is anticipated that all construction-related fine sediment would be flushed from the project reach within the first two to three storms following project completion.

Under both action alternatives, removal of reed canary grass and restoration of free-flowing channel is expected to improve water quality by increasing the dissolved oxygen in the stream, especially during summer low flow periods.

Cumulative Effects on Hydrology and Water Quality
The cumulative effects on hydrology and water quality in the Strawberry Creek project area are related to agricultural activities in the project area that altered the original vegetation and channel configuration and from invasion of reed canary grass into the wetland. Logging in the watershed, both in the Strawberry Creek watershed and the larger Redwood Creek watershed, has also affected hydrology and water quality. The most significant effect on hydrology and water quality in the Redwood Creek estuary resulted from construction of the flood control levees in the late 1960s, and logging and road building within what is now the national park and upstream of current park boundaries in the Redwood Creek watershed.

The effect of stream crossing removals and associated minor watershed restoration would be a benefit to the water quality in the Redwood Creek estuary but the benefit would be negligible because of the adverse effects of remaining abandoned roads and numerous unrestored stream crossings upstream and from the levees. The replacement of culverts and restoration of the Strawberry Creek channel would not improve hydrological conditions or water quality in Redwood Creek upstream of the project area.

Damage to forest resources and fish in the Redwood Creek watershed coincided with both intensive timber harvest and a series of large storms between 1955 and 1983 that were accompanied by widespread flooding and erosion. Land use activities significantly increased erosion above naturally high levels associated with storms. The large number of improperly designed and maintained roads, landings and skid trails in the Redwood Creek watershed causes increased surface erosion and fine sediment production and delivery, and an increased potential for stream diversions, rill and gully erosion, and road related landslides with corresponding increase in sediment production and delivery. Past timber harvest on unstable slopes in what is now the park and outside the park prior to the enactment of the state Forest Practice Rules and removal of riparian vegetation also contributed to increase erosion and sediment production. These factors led to the designation of Redwood Creek as a sediment- and temperature-impaired stream by the EPA under Section 303(d) of the Clean Water Act.

Key changes in Redwood Creek main stem channel structure over the past 40 years include increases in the volume of stored sediment; decreases in pool numbers and depth; increases in stream width and decreases in stream depth; reduced recruitment of large woody debris; deposition of high levels of fine sediment on the stream bottom; and reduced volumes of large woody debris. These effects are lessening as sediment moves down the channel and as new sediment sources are reduced through current road and forest management practices and road removal and watershed restoration projects.

In 1999, NPS researchers estimated that approximately 55% of 1,400 miles of roads in the watershed were not maintained and were therefore more likely to fail during storms than maintained roads. There are several thousand crossings associated with these roads and it is likely that hundreds of crossings continue to have potential to divert streams or deliver sediment into the creek.

Long-term improvement to the main stem of Redwood Creek from reducing sediment associated with Strawberry Creek culverts would be negligible because of the small amount of sediment removed from four stream crossings under either action alternative compared to the potential erosion volume remaining in the Redwood Creek watershed. A major storm would cause erosion in untreated logging roads in the Redwood Creek watershed, which would have additional significant adverse effects on water quality in Redwood Creek. The magnitude and duration of the adverse effects on water quality would be proportional to the magnitude and duration of the storm and the resulting high flows.

Gravel to form the substrate of the new stream channel would be imported from channel maintenance activities occurring within lower Redwood Creek between the levees, if available, or purchased from commercial sources. Removal of gravel and other current levee maintenance activities would not affect Strawberry Creek in and downstream of the project area.

On-going removal of reed canary grass and re-plantings of native trees and shrubs, and replacement of the undersized culvert at the Humboldt County Waste Transfer Station would affect the hydrology in the project area by improving the flow regime in the stream channel from the project area down to U.S. Highway 101. Removal of reed canary grass in the reaches downstream of the park would improve the chances of success in the project area by restoring more natural hydrologic processes and increasing dissolved oxygen along about 0.9 mile of Strawberry Creek. The persistence of the reed canary grass mat to the east of the project area in the park will continue to act as a sink for dissolved oxygen. The East Tributary will continue to flow through the wetland area before entering the restoration area, creating the potential for water quality in the East Tributary and Strawberry Creek suitable for salmonids to be compromised when low dissolved oxygen conditions occur. Topographic surveys indicate that most of the reed canary grass mat area to the east of the project area is characterized by low ground that is expected to remain inundated, even after restoration efforts downstream of the park are completed.

Predicted sea-level rise of 1.4 m (55 in) by the year 2100 due to global climate change is expected to slow the storm runoff from the project area and the stream velocity. This would cause stream and wetland areas to inundate additional lands adjacent to the project area more frequently than under the current sea level.

Conclusions: Effects on Hydrology and Water Quality

Effects of the Orick flood control levees on the water quality and hydrology of the Redwood Creek estuary would continue to be adverse and significant.

Effects on hydrology and water quality from continued removal of reed canary grass and re-planting of native trees and shrubs along about 0.6 miles of creek downstream of the project area and replacement of undersized culvert at the Humboldt County Waste Transfer Station would affect the hydrology in the project area by improving the flow conveyance in the stream channel. Removing reed canary grass to increase dissolved oxygen and re-establishing a free-flowing condition to the stream would be a moderate benefit to Strawberry Creek. The long-term benefits to water quality and hydrology in Strawberry Creek in the project area are dependent to some extent on restoration actions in the downstream reaches outside the park boundary.

Under the no-action alternative, water quality in Strawberry Creek would remain poor due to extremely low levels of dissolved oxygen. This would be a locally significant adverse effect on fish when dissolved oxygen falls to less than 5 mg/l. Erosion and sedimentation from SOC Road and the stream crossings in large storms would increase turbidity, which would be an adverse effect on water quality in Strawberry Creek. Over the short-term, the adverse effects from erosion related to the SOC Road and the stream crossings would be negligible. Over the long-term, there is a potential for moderate adverse effects in the wetland if a major storm causes a catastrophic failure of upslope stream crossings. The effects on water quality from stream crossing failures in the Strawberry Creek watershed due to a major storm would be indistinguishable from significant adverse effects on water quality throughout the Redwood Creek watershed.

Under the no-action alternative, hydrology of Strawberry Creek would continue to be significantly altered from its original condition as a free-flowing stream in an unaltered channel, subject to sedimentation from erosion from unmaintained logging roads upslope.

Under both action alternatives, there would be long-term beneficial effects to water quality and hydrology in the project area from excavating and realigning stream channels to restore free-flowing conditions, replacement of undersized culvert[s] with culverts designed to accommodate 100-year storm events, and removal of four stream crossings to reduce erosion. The benefits from installation of culverts sized to accommodate a 100-year storm event and removal of stream crossings is judged to be minor to moderate, depending on the intensity and duration of rainfall events. In the event of minor flooding (flows up to 10-year storm events), the benefit from removal of the stream crossings would most likely be negligible to minor. In large flood events (up to 25-year storm events) or intense rainfall over a period of weeks, there would be minor to moderate benefits to water quality from installation of adequately sized culvert[s] on the SOC Road that would convey high flows and from removal of stream crossings that could fail and deliver sediment into the wetland.

The multiple minimization measures prescribed by the Water Quality Control Board, the CDFW FRGP restoration manual, and the NOAA RC program to minimize degradation of water quality would reduce short-term adverse effects on water quality from turbidity due increased sediment in the stream for one to two rainy seasons until the newly excavated areas adjust to a new configuration. The long-term effects on water quality from turbidity after the excavated stream channels and crossings adjust to the new configuration would be negligible.

Equipment refueling, fluid leakage from equipment, and maintenance activities for construction equipment used in and near the construction area has the potential to contaminate water. The project would be implemented using the minimization measures outlined in the CDFW restoration manual and the NOAA RC programmatic biological opinion that address pollution risk. Therefore, water quality degradation from toxic chemicals associated with construction equipment would be negligible.

Under both action alternatives, removal of four upslope stream crossings would prevent an estimated 630 cu yd of sediment from being delivered into the wetland. This would have a negligible benefit on water quality in the Redwood Creek estuary, and no effect on hydrology in Redwood Creek upstream of Strawberry Creek and on the Redwood Creek estuary. Prevention of erosion of this volume of sediment would have a negligible to minor long-term benefit to the restored stream, depending on the size of storms that may cause erosion of the crossings.

The overall effects on water quality and hydrology in the project area from removal of reed canary grass, excavation to create free-flowing stream channels, and installation of larger culverts would improve the flow regime in the stream channel by increasing flow conveyance, and allowing free passage of 100-year flows. These effects are judged to be beneficial and moderate under both action alternatives.

EFFECTS ON FLOODPLAINS

No-action Alternative

Under the no-action alternative, the floodplain of Strawberry Creek would continue to be altered by the large expanse of reed canary grass that causes flows to spread out over the wetland (flow attenuation) and the undersized culverts on the SOC Road, both of which contribute to higher water levels and backwater effects within the wetland area. If the culverts fail to convey water in a large storm or plug with debris from upslope logged areas, eroded sediment would be delivered into the undefined Strawberry Creek channel, which would result in further channel aggradation. Channel aggradation would increase the volume of water that spreads out onto the wetland area.

Action Alternatives

Under both action alternatives, the new SOC Road culvert for the West Tributary would convey the 100-year flows.

Under Alternative 2 (the proposed action), the SOC tributary culvert would not be replaced. The existing culvert would not accommodate a 100-year flow event. Under Alternative 3, the SOC Tributary culvert would be replaced and would accommodate the 100-year flow but the newly restored SOC Tributary channel upstream of the culvert would not convey the 100-year flow. The SOC Tributary channel under Alternative 3 was designed for less than a 100-year event to ensure that the bed material inside the culvert would not be scoured at 100-year flows. Under both action alternatives, a 100-year event would result in flooding across the SOC Road and onto the alluvial fan on which former administrative facilities are located. Under both action alternatives, the SOC Tributary channel downstream of the SOC Road and culvert would convey the 100-year flows. The new channel downstream of the culvert was designed to allow for installation of an adequately-sized culvert (100-year event) if the SOC Tributary culvert is replaced in the future.

Under both action alternatives, high water levels during the wet season would persist across the entire floodplain and wetland complex, and above the banks of the new channel in some areas at some high flows. During the dry season, most of the flowing water would be contained within the channels. These overbank flows are intended to mimic natural conditions during high flows in low-gradient areas such as Strawberry Creek where it enters the Redwood Creek estuary. The estuary itself is a low-gradient area within its original floodplain.

Under both action alternatives, excavation of reed canary grass and channel restoration and realignment would improve conveyance of flows within the bankfull channel (two-year event), restoring a more natural condition for floodplain function. Instream structures would control channel width and slope to create reaches to transport or deposit sediment to maintain the shape and depth of the restored channel.

Cumulative Effects on Floodplains

The new channel downstream of the SOC Tributary culvert was designed to allow for installation of an adequately sized culvert (100-year event) if the SOC Tributary culvert is replaced in the future.

Restoration of Strawberry Creek on lands downstream of the park would contribute to proper functioning of the restored channel on park lands. Effects on the Strawberry Creek floodplain from on-going removal of reed canary grass along 0.6 miles of Strawberry Creek downstream of the park as needed to maintain flow conveyance and replacement of the undersized culvert at the Humboldt County Waste Transfer Station would improve the flow regime in the stream channel by increasing flow conveyance, lowering seasonally high water elevations, and allowing free passage of 100-year flows within the channel.

As watershed restoration projects are completed within and upstream of the park, the floodplain would gradually recover as excess sediment from unmaintained logging roads decreases. New logging roads in the Redwood Creek watershed upstream of the park are constructed and maintained to state Forest Practice Act standards which would decrease the volume of sediment delivered to the Redwood Creek floodplain. Lower Redwood Creek would continue to be confined by flood control levees that are designed to convey floodwaters to the ocean rather than being allowed to spread over the natural floodplain. At very high flows (greater than 200-year event), the levees would be overtopped and Redwood Creek would flow out into its original floodplain. The flood of December 1964, the flood of record for Redwood Creek, is estimated to have been a 50-year event.

Conclusions: Effects on Floodplains
Effects on the Strawberry Creek floodplain from on-going removal of reed canary grass along Strawberry Creek downstream of the park as needed to maintain flow conveyance and replacement of the undersized culvert at the Humboldt County Waste Transfer Station would improve the flow regime in the stream channel in the park project area under both action alternatives and in the reaches downstream of the park by allowing free passage of 100-year flows. These flows would be contained within the channel at low flows and would overtop the mounds at higher flows, spreading out onto the floodplain of Strawberry Creek. At very high flows (greater than a 200-year event), the floodplain of Strawberry Creek would be subsumed into the floodplain of Redwood Creek as the levees are overtopped.

Under Alternative 3, the restored SOC Tributary above the road nearest SOC would convey the 100-year event but the culvert would not accommodate this event. A 100-year event would overtop the road at this culvert and spread onto the floodplain. Although this may be considered an adverse effect to the extent that the road is overtopped, a 100-year flood would have catastrophic effects on other resources and on human life, health, and safety.

Under both action alternatives, there would be a benefit to the floodplain of Strawberry Creek from removal of the undersized culvert on the SOC Road; excavation and realignment to restore the stream channel; and excavation of flow-through and dead-end channels to accommodate flows within channels rather than allowing flows to spread out onto the floodplain. Excavation for channel realignment and mound construction under both action alternatives would have negligible short-term adverse or beneficial effects on the floodplain. As the riparian plantings shade out the channel to prevent reinvasion of reed canary grass, the long-term effects to the floodplain of Strawberry Creek would be moderate and adverse as higher flows are conveyed within the channels rather than spreading out over the floodplain. Privately-owned grazing lands outside the park would benefit from reduced flooding as flows are conveyed downstream more effectively.

As road removal and road upgrade projects are completed within and outside the park, and logging roads upstream of the park are constructed and maintained to standards in the state Forest Practice Act, there would be a moderate benefit over the very long-term to the floodplain of Redwood Creek. Restoration of the Strawberry Creek floodplain would have a negligible benefit to the Redwood Creek floodplain, because Strawberry Creek enters the Redwood Creek floodplain near the mouth at a point where the floodplain is confined by flood control levees.

The cumulative effect of the entire Strawberry Creek restoration project from NPS lands downstream to the South Slough would be a minor benefit to the floodplain of Strawberry Creek from replacing undersized culverts with culverts sized to accommodate 100-year flows and a minor benefit from restoration of portions of the stream channel. The floodplain outside the restoration areas would continue to be altered from past channelization and other alterations to support agricultural and residential uses.

EFFECTS ON WETLANDS

Wetlands are typically defined by three parameters–wetland hydrology, hydric soils, and hydrophytic vegetation. When all three wetland parameters are present, the wetlands are subject to regulation by the Corps under Section 404 of the Clean Water Act or Section 10 of the Rivers and Harbors Act, and identified as jurisdictional wetlands. The NPS uses the Cowardin classification system to identify wetlands (Cowardin et al. 1979.) Under this system, the “three-parameter” wetlands and additional shallow aquatic areas such as unvegetated stream channels are subject to the NPS policies for compliance with EO 11990 “Protection of Wetlands.” The functions and values of the Strawberry Creek wetlands within the NPS project area are summarized in Appendix B.

No-action Alternative.
Under the no-action alternative, there would be no impacts on wetlands or wetland functions and values from removal of four stream crossings; replacement of culverts on the SOC Road; excavation to establish stream channels; or placement of fill to create mounds for riparian planting (figure 6). The Palustrine Emergent wetlands would continue to be heavily impacted by invasive reed canary grass, and would continue to have high value as wildlife habitat for amphibians and birds and their predators. Wetland functions associated with riparian zones such as habitat for tree-nesting birds would be absent within the wetland due to lack of riparian vegetation.

Action Alternatives.
Under both action alternatives, long-term effects to the extent of adjacent wetlands from excavation and filling to create channels and planting mounds, are not likely. The purpose of the project is to create conditions suitable for maintaining a continuous open-water corridor through the existing wetland to provide habitat for anadromous fish. The design engineer indicated that the frequency or duration of inundation in the wetlands adjacent to the stream channel is not expected to change as a result of excavation to

create the channel or from the creation of the planting mounds (Michael Love and Associates, Arcata, CA, email to Darci Short, NPS, Arcata, September 25, 2013). However, the potential changes to surface and subsurface water levels throughout the year as the result of project implementation are uncertain. The timing, duration, and distribution of wetland water levels, both surface and subsurface, may be affected by the project. Although changes to water levels are anticipated to be permanent, the extent of the Corps Jurisdictional wetland is not expected to change. Plant communities and wetland functions may adjust as the result of the shift from Permanently Flooded to an Intermittently Flooded Palustrine Emergent wetland.

Wetland extent within the project area is controlled by surface and subsurface hydrology, and subtle changes in topography. The primary landforms are the alluvial fan (upland) deposited by Strawberry Creek as it flows onto the adjacent, low gradient floodplain (wetland). The wetland-upland boundary follows the distal (northern) extent of the alluvial fan along the contact with the floodplain. These alluvial fan-floodplain landform relationships are common on alluvial plains elsewhere in Humboldt County.

Soils in the Strawberry Creek wetland are mapped primarily as the Arlynda soil series (figure 2, table 3). The Arlynda soil series, a wetland (hydric) soil, is often mapped (map unit 119) on meander scars, adjacent to backwater channels, along the margins of alluvial fans, and on lower reaches of streams and rivers. Arlynda soils are very poorly drained and typically have standing water of a few inches to two feet in depth from December through February and groundwater within 12 inches of the soil surface from March into early May. Typical vegetation is cultivated pasture grasses and forbs, and native rushes and sedges (USDA NRCS 2008, 2013).

The Arlynda soils mapped in the project area tend to have a much thicker surface organic layer of peat than do Arlynda soils in other parts of Humboldt County. The thicker surface layer of peat is a result of the densely vegetated floating mat and standing water one to three feet deep throughout the year. Annual die-off of plant material decomposes very slowly in standing water that lacks oxygen. Plant communities are dominated by cattails where the standing water is deepest, with a mosaic of forbs, rushes, sedges, and grasses throughout the wetland. Changes to water levels as a result of the channel excavation under both action alternatives may shift from current Permanently Flooded conditions to an Intermittently Flooded Palustrine Emergent wetland more typical of an Arlynda soil hydrologic regime.

The data from two stations monitoring water surface elevations display water levels in the channel at the northern NPS property boundary, and another nearby in the Palustrine Emergent wetland (figure 4). Three years of data suggest that downstream restoration efforts, primarily removal of reed canary grass and minor channel modifications, have had little or no effect on water levels on NPS property. In the summer and fall of 2007, removal of reed canary grass from the active channel from two stream reaches downstream caused water levels to drop by three feet during winter baseflow conditions throughout this 3,400-foot-long section of channel (Love 2008). Fifteen additional stations to monitor water levels and plant species have been established to assess the effects of the proposed restoration on water levels and plant communities in the wetland.

There would be short-term impacts to soils from mobilization and access for heavy equipment needed for construction. Two temporary roads would be constructed for the heavy equipment access, one approximately 100 ft in length for access for channel excavation and mound construction, and one approximately 180 ft in length for replacement of the SOC Road culvert over the West Tributary. The temporary access road for heavy equipment access would affect about 200 sq ft of Palustrine Emergent wetlands. The temporary road to bypass the culvert replacement site would be entirely within the wetland; it would be removed and the material incorporated into the West Tributary planting mounds.

Under both action alternatives, soils and vegetation within the limits of disturbance for construction within the wetland area would be excavated to create main and side channels and planting mounds. Areas cleared of grasses that are not within restored channel or shaded by trees on the planting mounds would require hand-pulling of grasses for several years to prevent invasive grasses from re-establishing. The constructed planting mounds are intended to provide an area above seasonal high wetland water levels of 22 ft to support the growth of Sitka spruce.

Table 6 shows the areas of Cowardin wetland types and conversions of Corps wetlands and waters of the U.S. under the proposed action (Alternative 2) and Alternative 3.

Under the proposed action (Alternative 2), the mound area above 22 ft is anticipated to be converted from three-parameter wetland to upland and encompass about 0.91 ac. About 0.53 ac of the mounds will be below 22 ft and is anticipated to remain a three-parameter Palustrine Emergent wetland. The 0.53 ac that are presently dominated by reed canary grass with some areas of slough sedge and cattail would be planted with native willow, sedges, and alder.

In addition to conversion of wetland to upland, there would be a conversion of wetland to waters of the U.S. of 0.37 ac under the proposed action (Alternative 2). Under Alternative 3, about 0.23 ac of wetlands would be converted to upland and about 0.42 ac of wetlands would be converted to waters of the U.S.

The planting scheme on the mounds under Alternative 3 is based on elevations above mean sea level and would be similar to the proposed action. These plantings would increase habitat diversity in the project area by creating a riparian zone, thus increasing the suitability of the area for tree-nesting birds and small and medium-sized mammals.

TABLE 6. AREA OF COWARDIN WETLAND TYPES AND CONVERSIONS UNDER ALTERNATIVES 2 AND 3.

Wetland Type	Acres
Alternative 2	
Cowardin Wetland Type	
Riverine wetland (channel bankfull)	0.26*
Riverine wetland (channel endpool)	0.03*
Riverine wetland (side channel)	0.08*
Palustrine Emergent wetland (floodplain)	0.34
Palustrine Forested wetland (planting area)	0.03
Palustrine Emergent wetland (17’<mound<22’)	0.53
Total (at 22 ft and below)	1.27
Corps Wetland to Waters of US	0.37*
Corps Wetland to upland	0.91
Alternative 3	
Cowardin Wetland Type	
Riverine (channel bankfull)	0.30*
Riverine (channel endpool)	0.03*
Riverine (side channel)	0.09*
Palustrine Emergent (floodplain)	0.34
Palustrine Forested (planting area)	0.03
Palustrine Emergent (17’<mound<22’)	0.51
Total (at 22 ft and below)	1.30
Corps Wetland to Waters of US	0.42*
Corps Wetland to upland	0.23

The predicted benefits of both action alternatives to the wetland-riparian-riverine complex were quantified using the California Rapid Assessment Method (CRAM). (CWMW 2009, 2012; Brown and Hancock 2012; NPS, Seney 2013). CRAM is a diagnostic tool used to assess wetland condition. It is intended to “provide rapid, scientifically defensible, standardized, cost-effective assessments of the status and trends in the condition of wetlands and related policies, programs and projects throughout California” (CWMW 2012). Information gathered using CRAM methods allows for recurring and consistent data to be compared and evaluated over the long term.

The assessment was completed on three riverine reaches and one wet meadow area (figures 7 and 8). CRAM assessment scores predicted after restoration under both action alternatives (table 7) were developed by NPS staff using project designs and objectives and methods described in the CRAM Manual (CWMW 2012).

Figure 7. Riverine reaches assessed in the current condition CRAM report. (Brown and Hancock 2012). Reach B is outside of the project area footprint.

The current condition overall attribute scores for the three riverine reaches ranged from 57 to 61. For the wet meadow area, the overall attribute score was 75 (table 7). All sites scored high (A or B condition) for Buffer and Landscape context and Hydrology, with the buffer condition metric the lowest scoring metric with C condition scores. The Physical and Biotic Structures attribute scores are primarily C or D condition, and are a result of a non-functioning floodplain; plant communities dominated by invasive species, and a lack of topographic complexity in the wetland.

The post-restoration overall attribute target scores for riverine reaches A and C, the two assessed sites within the restoration project area, are 82 and 85. The increase in overall attribute scores, for Reach A is 57 to 82 and Reach C is 59 to 85. These increases can be attributed to creating a well-defined, stable channel with a functioning floodplain with abundant large woody debris embedded in the channel, addition of side channels and sloping mounds adjacent to the main channel, removal of invasive plant species, and planting of native riparian species.

Comparison of pre- and post-project CRAM scores predicted a substantial increase in wetland functions from proposed restoration actions and an overall long-term benefit to wetland functions. The post-project scores were higher than the existing conditions, indicating that the project would have an overall beneficial effect on the wetland-riparian-riverine complex by creating a well-defined, stable channel with a functioning floodplain that would have abundant large woody debris embedded in the channel, addition of side channels and sloping mounds adjacent to the main channel, removal of invasive species and planting of native riparian species.

TABLE 7. CRAM ATTRIBUTE SCORES

The first row identifies the specific riverine reach and wet meadow complex that was evaluated. Subsequent rows display CRAM attribute scores for specific metrics for pre-project (current) conditions and anticipated future (post-project) conditions. The optimum score for each metric is an "A" condition. Each letter scored is converted to a numeric value and weighted to arrive at attribute and overall scores (CWMW 2009).

Attri-butes	Metrics	Reach A		Reach B	Reach C		Meadow
		Current	**Post-project**	**Not in project**	**Current**	**Post-project**	**No Change**
Buffer and Landscape Context	Landscape Connectivity	B	B	A	A	A	A
	Buffer Sub-metrics:						
	- Percent of Assessment Area with buffer	A	A	A	A	A	A
	- Average Buffer Width	A	A	B	A	A	B
	*-Buffer Condition	C	B	C	C	B	C
	Attribute Score	71%	79%	83%	85%	92%	83%
Hydrology	Water Source	A	A	A	A	A	A
	**Hydroperiod or Channel Stability	C	A	C	C	A	A
	Hydrologic Connectivity	A	A	A	A	A	A
	Attribute Score	83%	100%	83%	83%	100%	100%
Physical Structure	***Structural Patch Richness	C	B	C	C	B	B
	***Topographic Complexity	D	C	D	D	C	C
	Attribute Score	38%	63%	38%	38%	63%	63%
^Biotic Structure	Plant Community Sub-metrics:						
	- Number of Plant Layers	B	A	B	A	A	na
	- Number of Co-dominant Species	D	B	C	D	B	B
	- Percent Invasion	D	B	D	D	B	D
	- Number of Encroachment Species	na	na	na	na	na	A
	Horizontal Interspersion and Zonation	D	A	D	D	A	D
	Vertical Biotic Structure	C	B	C	C	B	B
	Attribute Score	39%	86%	41%	33%	86%	55%
	Overall Score	**57**	**82**	**61**	**59**	**85**	**75**

*Buffer for assessment area will be dominated by native vegetation with little or low impact human visitation.
**Channel will be well defined with an obvious active floodplain; riparian vegetation will be abundant along banks; channel will contain embedded large woody debris.
***Structural Patch Richness and Topographic Complexity will be enhanced by creation of side channels and sloping mounds.
^Biotic Structure will be enhanced by removal of invasive grasses and planting of native riparian and forest vegetation.

Figure 8. Wet meadow assessment area (Brown and Hancock 2012)

Cumulative Effects on Wetlands

Riparian areas and wetlands in the proposed project area and along Redwood Creek and its more heavily logged tributaries have been destroyed or degraded by logging and road construction in the mid-1900s, and the effects of subsequent erosion. The greatest benefit to riparian area and wetlands in the park upstream of the project area relies on the effectiveness of watershed restoration at preventing erosion that would lead to landslides that could bury riparian areas and wetlands with sediment.

Wetland values of the Redwood Creek estuary have been significantly altered by upstream land uses, especially logging and associated road construction, and flood control levees. Prior to channelization of lower Redwood Creek for flood control and draining, diking, and channelization of tributaries including Strawberry Creek, wetland values of lower Redwood Creek included flood attenuation and habitat for wildlife and fish, including threatened fish species. The levees have assumed the flood attenuation function.

Other past, present, and reasonably foreseeable actions that affect wetlands in the vicinity of the project area include removal of reed canary grass and riparian plantings along 0.6 mi of Strawberry Creek downstream of the park and proposed replacement of an undersized culvert at the Humboldt County Waste Transfer Station. Hand-pulling to remove reed canary grass will continue to maintain a clear channel, as well as replacing plantings to create shade to retard re-establishment of the reed canary grass.

Strawberry Creek originates on park lands and flows through private and public lands under several different ownerships. Success of the project depends on controlling reed canary grass throughout the length of the stream to maintain a channel for fish passage from the estuary upstream to the project area.

The persistence of the reed canary grass east of the project area will continue to act as a sink for dissolved oxygen. The East Tributary will continue to flow through the reed canary grass before entering the restoration area, which may result in low dissolved oxygen levels in the East Tributary and Strawberry Creek at low flows. Topographic surveys indicate that most of the wetland east of the project area is characterized by low ground that is expected to remain inundated at least intermittently, even after restoration efforts are completed.

Conclusions: Effects on Wetlands

Under the no-action alternative, the wetlands in the project area would continue to function at a lower level as indicated by the CRAM scores for the current conditions. There would be no short- or long-term adverse effects from restoration actions. There would be no long-term benefits as indicated by an increase in CRAM scores under the no-action alternative.

The project has been designed to create conditions suitable for maintaining a continuous open-water corridor free of invasive aquatic vegetation through the existing wetland for use by aquatic organisms. Under both action alternatives, excavation for channels would require grubbing and removal of existing vegetation which is generally composed of mats of invasive reed canary grass, other invasive grasses and localized areas of slough sedge, common rush and other native species. The purpose of the constructed planting mounds is to provide an area above seasonal high wetland water levels of 22 ft to support the growth of Sitka spruce. After project implementation, native willow, sedges, alder and some Sitka spruce planted on the upper portion of the mounds would increase habitat diversity by creating a riparian zone, thus increasing the suitability of the area for small and medium-sized mammals and nesting birds. As indicated by the increase in CRAM scores, there would be a moderate long-term benefit to wetlands from restoration.

There would be a potential for minor adverse effects on wetlands associated with Strawberry Creek from all alternatives, including no-action and the two action alternatives. The potential impacts to surface and subsurface water levels throughout the year as the result of project implementation are uncertain. The timing, duration and distribution of wetland water levels, both surface and subsurface may be affected by the project. Any changes to water levels are anticipated to be permanent but the Corps Jurisdictional wetland extent is not expected to change. Water levels and vegetation composition in and around the project area would be monitored for five years to determine effects of the project on adjacent wetlands. Continued removal of reed canary grass and replanting with native vegetation as needed along about 0.6 mi of Strawberry Creek would restore natural functions and values associated with a riverine wetland downstream. Neither action alternative is expected to reduce overall wetland extent, both within, downstream, and adjacent to the project area.

EFFECTS ON VEGETATION

No-action Alternative

Under the no-action alternative, invasive reed canary grass would continue to dominate the project area and the surrounding 30 ac in the park. The conversion of the Strawberry Creek floodplain from free-flowing stream and Sitka spruce-dominated Palustrine Forested wetland to agricultural pasture allowed invasive reed canary grass to colonize much of the stream channel and adjacent riparian wetlands. Reed canary grass prohibits riparian growth by creating a dense mat; chokes the stream channel which inhibits the mobility of fish at lower flows; increases sedimentation of the channel by capturing sediment; contributes to low levels of dissolved oxygen; reduces flow conveyance; and causes overbank flooding of the shallow poorly defined channel during winter and spring base flow conditions. There would be no direct impacts to existing wetland vegetation and upslope forested areas under the no-action alternative.

Action Alternatives

Under both action alternatives, approximately 19,200 sq ft (0.44 ac) of vegetation would be affected by removal of the four stream crossings. The stream crossings are covered almost entirely by vegetation, primarily red alder, small Sitka spruce, berries, and other shrubs. Vegetation grubbed out prior to excavation would be stockpiled nearby and replaced as mulch on the disturbed soils following excavation of the crossings. The area would be allowed to revegetate naturally from the seed bank in the mulch and from the adjacent areas. Natural revegetation occurs quickly in the moist heavily vegetated project area. Understory vegetation would re-grow within several months depending on the severity of the following winter and would be completely regrown within 2-3 years.

The largest trees that would be cut for excavation and restoration of the four stream crossings would be red alders and Douglas-fir less than 20 in dbh. No old growth or mature conifers would be removed. Adverse effects from removal of vegetation for upland restoration would be negligible because the vegetation present is regrowth following the original disturbance from road construction, is widespread throughout the region, and would recover in one to two growing seasons.

Under Alternative 3 only, the realigned channel upstream of the SOC Road would be excavated within an open area to minimize root damage to established large alders and spruce trees. Under Alternative 3, West Tributary restoration would bring the new channel very close to the roots of two 24-in dbh Sitka spruce trees. Under the proposed action (Alternative 2), the channel alignment was moved about 50 feet to the south to avoid removing the trees or damaging their roots.

Under both action alternatives, reed canary grass and other vegetation would be grubbed prior to excavation, hauled about 800 yards, and stockpiled in an area formerly used to store maintenance supplies and other equipment in the administrative area at the former SOC. Under Alternative 2 (the proposed action), invasive grasses would be grubbed only within the limits of the 25-foot riparian buffer, under the planting mounds, and within the channel excavation areas. Vegetation would be grubbed from approximately 2.2 ac of wetland for channel realignment and mound construction and 0.68 ac of non-wetland for channel realignment under Alternative 2.

Under Alternative 3, invasive grasses would be grubbed from within the entire project area. Vegetation would be grubbed from approximately 3.1 ac for channel realignment and mound construction and 0.8 ac in non-wetland areas for channel realignment under Alternative 3.

Suitable soils excavated to construct stream channels would be used to create mounds, which would be planted with riparian vegetation, nursery-grown from seed or cuttings collected on site. The planting mounds are expected to create dry ground surfaces above the seasonally high water level.

Planting areas include the mounds and the 25-foot riparian buffers, with willow cuttings along the restored channel where there are no mounds. The planting scheme would be three-year-old bare-root stock spruce, alder, and willow. Willow cuttings are intended to stabilize streambanks. While willow is not optimum for shading reed canary grass due to its deciduous nature and slower leaf-out time, it is ideal for its ease of planting and rapid establishment. Riparian plantings are intended to shade the channel to prevent reinvasion of reed canary grass. The planting mix contains a high percentage of spruce that grows rapidly and provides winter shade to retard regrowth of reed canary grass throughout the year, combined with rapid-growing deciduous shrubs that often form thickets to create dense shade year round.

Under Alternative 2 (proposed action), the alignment of the West Tributary and the gaps between the mounds would have a more west-to-east orientation than under Alternative 3 to maximize shading provided by the planting mounds. The planting mound locations under the proposed action differ from locations under Alternative 3 so that mounds under Alternative 2 completely shade restored channels of Strawberry Creek and the West Tributary. Under the proposed action only, log crib walls would be installed at gaps between the mounds to minimize sunlight penetration and inhibit regrowth of reed canary grass (figure A-15).

Under the proposed action (Alternative 2), the plantings would consist of 0.6 ac of Sitka spruce; 0.75 ac of Sitka spruce-alder mix; 0.25 ac of alder; and 0.36 ac of willow/sedge. Under the proposed action only (Alternative 2), nurse logs sprigged with Sitka spruce would be installed near the wetland side-channels to increase riparian shading.

Under Alternative 3, planting areas would consist of 0.92 ac of Sitka spruce-alder mix and 0.76 ac of willow and sedges.

Cumulative Effects on Vegetation

Cumulative effects on vegetation in the national park outside the project area are dependent on sufficient funding to implement projects. Projects that could be undertaken include restoration of second growth forest through thinning of dense stands left after logging prior to park establishment; fire management with fuel reduction, and prescribed fires primarily in the Bald Hills; invasive plant control throughout the parks; and watershed restoration to remove abandoned logging roads.

Logged areas of the parks outside project areas actively managed for watershed and forest restoration would continue to recover although the recovery in some dense second growth stands that were not thinned after replanting would require centuries to attain characteristics and functions associated with old growth forest.

Downstream of the project area outside the park boundary, restoration of Strawberry Creek would entail grubbing of reed canary grass along 0.6 mi of the stream channel, replanting with native riparian species, and installation of 4,000 lf of livestock exclusion fence to protect the newly planted streambanks. Replacement of the undersized culvert at the Humboldt County Waste Transfer Station would have negligible effects on vegetation.

Conclusions: Effects on Vegetation

None of the alternatives, including no-action and the proposed action, would affect vegetation in the Redwood Creek estuary. Under the action alternatives, the adverse primary impact to vegetation is the removal of reed canary grass and other vegetation in the wetland complex and replanting on the mounds to create shade to retard re-invasion of reed canary grass. Removal of the four stream crossings would affect about 0.44 ac of vegetation species that are common throughout the park and that are routinely removed for road and trail maintenance. The impact from removal of native vegetation mixed with the reed canary grass and at the upslope stream crossings is considered adverse and negligible. Removal of invasive reed canary grass is considered a moderate beneficial impact within the project area and along 0.6 mi downstream of the park but a minor benefit to the Strawberry Creek watershed in the park in which 30 ac would continue to be dominated by reed canary grass.

EFFECTS ON NON-SENSITIVE FISH AND WILDLIFE

No-action Alternative

Under the no action alternative, there would be no direct effects on non-sensitive wildlife and fish from construction associated with restoration activities. The adverse effect on wildlife from continued use and maintenance of the SOC Road would be negligible. There would continue to be long-term effects on wildlife from human presence in the Orick valley, including use and maintenance activities at the park residence and elsewhere in the former administrative area.

Action Alternatives

Under both action alternatives, there would continue to be long-term effects on wildlife from human presence in the Orick valley, including use and maintenance activities at the park residence and elsewhere in the former administrative area. Larger species of wildlife that occupy the area are accustomed to the presence of humans in the Orick valley.

Under both action alternatives, there would be temporary adverse effects on wildlife from noise and disturbance associated with construction. Fish screens would be installed to prevent individuals of threatened fish species from entering the project area during construction. Threespine stickleback that are in the project area when fish screens are placed would be confined within the construction area. These fish could possibly die, depending on the length of time the screens are in place. Sedentary wildlife that live within or immediately adjacent to the excavation sites would be subject to noise during construction and any soil or ground-dwelling organisms that live within the project site would be displaced or destroyed. There would be disturbance to birds and small mammals within the construction area during equipment operations. Mammals such as deer, elk, raccoons, foxes, skunks, and bears would avoid the area during construction but would probably be present at night after disturbance ceases. The effect on wildlife species that are not tolerant of human presence and that can move out of the area would be adverse, short-term and negligible to minor depending on the species and its tolerance of humans. For those individuals that are permanently displaced from their territories or are killed by equipment, the adverse effect is long-term or permanent, and major. There is sufficient habitat in the vicinity of the project area for persistence of all non-sensitive fish and wildlife species that could be affected by construction, and therefore, there would be no long-term adverse effect on park populations of any non-sensitive wildlife or fish species.

Cumulative Effects on Non-Sensitive Fish and Wildlife

The logging and agricultural activities that occurred in the project area prior to park establishment and expansion had significant adverse effects on some terrestrial and aquatic species of wildlife. Widespread loss of forest habitat and damage to streams from channelization and livestock grazing directly affected some wildlife and fish species. Aquatic species were directly affected where stream channels were blocked with Humboldt crossings (stream crossings constructed by placing logs in the channels and covering with soil instead of installing culverts or bridges) and indirectly affected by sedimentation of streams from landslides and erosion from bare slopes. The adverse effects of sedimentation in Redwood Creek and the estuary have continued after forest vegetation regrew. Several species that suffered major population declines from loss of forest habitat due to logging throughout their range are listed as threatened under the federal or California endangered species acts.

Restoration of Strawberry Creek downstream of the project area and replacement of the undersized culvert at the Humboldt County Waste Transfer Station would have a negligible effect on wildlife.

Conclusions: Effects on Non-Sensitive Fish and Wildlife
Grubbing to remove invasive grasses and excavation to remove stream crossings and realign stream channels would cause direct disturbance to individuals of small species of wildlife that are relatively sedentary such as ground-dwelling invertebrates, amphibians, and shrews. This would be a significant adverse effect on those individual animals that are displaced or killed. There would be negligible effects on larger more mobile species of wildlife that inhabit the project area and are able to move away from areas of disturbance. Individuals such as birds and small mammals that are temporarily displaced or disturbed by noise would reoccupy the project area when disturbance ceases and construction is completed. The overall adverse effect on wildlife would be negligible because those animals are common in the area, would be able to find refuge in the undisturbed areas adjacent to the project area, or would reoccupy the project area after construction.

There would be a benefit to wildlife species that inhabit riparian and stream habitats. The benefit would be negligible over the short-term until the riparian plantings are sufficiently established and a minor benefit in the project area over the long-term. The overall benefit to park wildlife would be negligible because stream and riparian habitat is common elsewhere in the park and because there would continue to be about 30 ac of Palustrine Emergent wetland habitat adjacent to the proposed restoration area where reed canary grass remains.

EFFECTS ON SENSITIVE, THREATENED, OR ENDANGERED SPECIES

Sensitive Plants

There are no state- or federally listed plants in the project area that would be affected by any of the alternatives, including the no-action alternative or the proposed action.

Effects on Threatened Birds under No-action Alternative
There would no project-related effects to threatened birds or other sensitive wildlife under the no-action alternative.

Effects on Threatened Birds under Action Alternatives
Removal of vegetation on 0.44 ac at the four stream crossing would be conducted outside the nesting season (May 1–July 31) to avoid impacts to nesting migratory birds protected under the Migratory Bird Treaty Act.

The NPS completed informal consultation with the USFWS for potential effects on the northern spotted owl and marbled murrelet from the proposed action. These effects would be similar under the more extensive restoration alternative (Alternative 3). The federal candidate Pacific fisher and state-listed bald eagle also were included in the *Biological Assessment of Impacts to Terrestrial Threatened, Endangered and Candidate Species from the Streelow Creek Trail Improvements, Tall Trees Trail Reroute and Strawberry Creek Watershed Restoration Projects in Redwood National and State Parks* (Schmidt and Bensen 2009). Impact analyses resulted in determinations of “may affect, but not likely to adversely affect” northern spotted owls, and “no effect” to marbled murrelets. The USFWS concurred with the NPS determinations in a memorandum dated June 9, 2009 (ref. no. 8-14-2009-3622 81331-2009-I-0105).

No suitable habitat for marbled murrelets or their designated critical habitat would be affected by the proposed action. There would be a slight amount of degradation of potentially suitable spotted owl habitat from removal of understory vegetation for stream crossing removal. This habitat would recover in less than five years as shrubs and trees recolonize the restored stream crossings.

The project would have no direct adverse effects on northern spotted owls or marbled murrelets from noise disturbance because the heavy equipment work for removal of the four stream crossings would not take place within 0.25 miles of suitable nesting habitat during the annual noise restriction period (Feb.1-Sept. 15 inclusive for both species).

Cumulative Effects on Threatened Birds

Spotted owls and marbled murrelets that nest in habitat adjacent to private timberlands would continue to be subject to increased noise disturbance from heavy equipment being operated on private lands. Murrelets would be subject to increased predation threats if corvid populations increase in the Orick valley and the surrounding area.

Cumulative effects on northern spotted owls would result from several factors. As a result of the most recent review of the condition of the northern spotted owl, the revised USFWS recovery plan identified past habitat loss, current habitat loss, and competition from recently arrived barred owls as the most pressing threats to the owl (USFWS 2011). However experimental barred owl removal taking place on tribal and non-NPS lands in the vicinity of the park could result in fewer barred owls and help reverse the downward population trend of spotted owls (USFWS 2013a, b).

On-going projects for which consultations with the USFWS have been completed and for which the USFWS concurred with the NPS determinations that the projects may affect but are not likely to adversely affect northern spotted owls or marbled murrelets are management of non-native plants throughout RNSP (USFWS 8-14-1999-77); management of Port-Orford-cedar in the northern part of the parks (USFWS 8-14-2004-2134; 81331-2010-I-0038); fire management in the national park (USFWS Ref. 8-14-2008-3562); and issuance of special use permits/commercial use permits (USFWS 8-14-1999-73, 81331-2009-I-0108).

In 2013, the NPS reported potential incidental take in Redwood National and State Parks of marbled murrelets and northern spotted owls authorized under several USFWS BOs (ref. nos. AFWO-11B0077-11F0076, 1-14-98-F-24, 8-14-2003-1517, 8-14-2004-2133, 8-14-2006-2836, 81331-2008-F-0027, 81331-2008-F-0310) although not all these projects resulted in incidental take in 2013. There was no incidental take associated with law enforcement or fire management helicopter use during noise restriction periods applicable to owl or murrelet habitat.

Projects for which take of murrelets or spotted owls due to noise disturbance and/or visitor use of facilities was reported in 2013 were annual maintenance of facilities, roads, and trails [Annual Maintenance (Facilities, Roads, and Trails) BO ref. no. 81331-2008-F-0130] and park visitor use of existing roads and campgrounds (Trail and Backcountry Management Plan BO ref. no. 8-14-2003-1517). Approximately 10,544 ac of suitable marbled murrelet habitat were subjected to increased predation threat due to park activities and/or park visitor use (NPS, Bensen 2013) Potential incidental take of marbled murrelets occurred on approximately 3,314 ac of potentially occupied suitable habitat from noise disturbance. Approximately 2,160 acres of unsurveyed spotted owl habitat was potentially impacted by noise disturbance.

Conclusions: Effects on Threatened Birds

There would be no direct adverse effects on northern spotted owls or marbled murrelets under any of the alternatives, including no-action and both action alternatives. There would be indirect adverse effects on northern spotted owls under both action alternatives from a slight amount of degradation of potentially suitable owl habitat from removal of understory vegetation for stream crossing removal. This adverse effect would persist for no more than five years and is judged to be negligible over the long-term.

Effects on Threatened Fish under No-action Alternative

Under the no-action alternative, there would be no direct effects on threatened fish or designated critical habitat from restoration actions. There would continue to be long-term indirect adverse effects on sensitive and threatened anadromous fish species to the extent that formerly suitable habitat once occupied by some life-stages of anadromous fish cannot support fish because of low dissolved oxygen or because the fish cannot access the habitat.

Effects on Threatened Fish under Action Alternatives

Proposed restoration of Strawberry Creek on NPS lands under both action alternatives would not directly affect CC Chinook salmon. CC Chinook salmon do not occur in the project area but do occur in the Redwood Creek estuary downstream of the project area. Both action alternatives have the potential for negligible short-term adverse effects from sediment released during instream work, and long-term benefits to CC Chinook salmon from the reduction of sediment that would eventually be delivered into the South Slough and the Redwood Creek estuary if the upslope stream crossings fail catastrophically.

Both action alternatives have the potential to affect SONCC coho salmon and NC steelhead and their designated critical habitat. The type and duration of effects of each alternative are essentially the same under each alternative. Effects under Alternative 3 (more extensive restoration) have a slightly greater intensity because an additional undersized culvert under the SOC Road would be replaced with a fish-friendly culvert and an additional 500 feet of channel excavated and restored on the SOC Tributary above the former administrative offices.

Under both action alternatives, removing the culvert that is currently a fish barrier on the West Tributary and providing access to 1,600 feet of restored channels would increase the amount of available habitat for threatened anadromous fish species. Removal of non-native plants from the stream channel would improve water quality by increasing dissolved oxygen, thereby improving habitat conditions for fish. Reducing potential sediment threat from erosion into Strawberry Creek by removing the four upstream stream crossings would have a long-term benefit to fish.

Excavation of the four upslope stream crossings would prevent an estimated 630 cu yd of sediment from being delivered into Strawberry Creek. During the first rainy season following excavation, a maximum estimated 24 cu yd of soil would erode as the newly excavated channels adjust. The stream channels are generally filled with wood debris from past logging disturbances. The presence of wood debris and the distance between the stream crossing excavation sites and potential fish habitat downstream is expected to attenuate sediment delivery to fish habitat in the newly created stream channels.

There would be no adverse effects on listed fish from short-term noise, motion, or vibration of heavy equipment to remove vegetation, excavate the channel, or install instream structures in the wetland or West Tributary because there are no listed fish in these areas. Equipment refueling, fluid leakage, and maintenance activities for construction equipment used in and near the wetland and West Tributary channel has the potential for contamination and potential take of listed fish. The project would be conducted using the multiple mitigation measures outlined in the CDFW restoration manual and associated biological opinions that address and minimize pollution risk. Therefore, potential adverse effects on listed fish from water quality degradation from toxic chemicals associated with habitat restoration projects would be negligible.

Cumulative Effects on Threatened Fish

Anadromous fish stocks throughout the Pacific Northwest region are threatened by the cumulative impacts of livestock use adjacent to streams, road construction, timber harvest, stream channelization, water diversions, hydroelectric development, overfishing, and the influence of hatchery fish on both disease resistance and genetic fitness of native stocks (USDC 1997a and 1997b).

Although little scientific data are available for accurate estimates of past salmonid populations in Redwood Creek, the limited data available indicate that the anadromous fishery of Redwood Creek has experienced a substantial reduction over historic levels. Present populations of salmonid species are well below those reported in historical accounts. The earliest accounts circa 1890 reported Redwood Creek as having supported a substantial salmonid fishery (Van Kirk 1994).

Degraded stream habitat is a major contributor to the decline in numbers of salmon and trout in the region. The combined effects of timber harvest in the past century (i.e., removal of forest cover and construction of logging roads) and major flood-producing storms have deposited large amounts of sediment in Redwood Creek and degraded habitat. Accelerated erosion caused sedimentation of the main stem that filled deep pools. Major flood events caused significant channel alterations including channel widening, aggradation, and bank erosion. The resultant widened streambed and shallow riffles provide little or no cover for fish. Sedimentation negatively affects egg survival and fry emergence, and fish food organisms, i.e. benthic invertebrate production. Other factors contributing to and exacerbating population declines are natural events including severe floods, extended drought and poor ocean conditions, overfishing, and the prolonged effects of past hatchery practices.

In 1998, EPA Region 9 designated Redwood Creek as sediment-impaired and established a Total Maximum Daily Load (TMDL) for sediment for Redwood Creek under Section 303(d)(1)(A) of the Clean Water Act. The Redwood Creek TMDL describes fish populations in Redwood Creek as “much reduced” compared to historic accounts. Habitat conditions are still degraded relative to pristine conditions but are showing signs of improvement. Although channel deepening and pool development have been observed in all but the lower few miles of Redwood Creek, the main stem generally lacks an adequate pool-riffle structure and cover. Coarse sediment deposited in the main stem allows a large proportion of the summer base flow to infiltrate and flow subsurface, thereby limiting the surface water available to fish and increasing surface water temperatures. Spawning habitat in Redwood Creek is slowly improving as gravels are cleaned of fine sediment. Tributary water temperatures are generally suitable for salmonids but suboptimal along much of the main stem.

Future NPS actions anticipated within the project area include removal of remaining structures in the former park administrative area (excluding the residence). Restoration of the Redwood Creek Estuary including potential removal of the portions of the flood-control levees is proposed in the 1999 RNSP GMP/FEIS. Restoration of the Redwood Creek Estuary through levee modification would have significant short-term adverse effects from sediment release during levee reconfiguration and long-term benefits to listed fish from habitat restoration.

Other on-going projects for which the NPS has completed consultations with NMFS for potential effects to listed fish species throughout the park include annual and periodic road maintenance (NMFS biological opinion and letter of concurrence 151422SWR02AR6347, March 2003; Ref, 2007/09110, August 2008) and fire management (NMFS biological opinion Ref. 2009/04519, February 2010). The NPS requested incidental take for CC Chinook salmon, SONCC coho salmon, and NC steelhead under the NPS biological assessment prepared in 2003 for the Annual and Periodic Road Maintenance program, and the 2006 addendum. NMFS biological opinion (Ref. No. 2007/09110) issued in August 2008 authorized an unquantified amount of take based on miles of stream affected.

The Humboldt County Waste Transfer Station culvert is only passable for adult salmon and steelhead during flows that provide sufficient water depth within the culvert. The lack of depth and excessive velocities within the existing culvert, combined with a small outlet drop create a complete barrier for adult resident trout and juvenile salmonids. Replacement of the undersized culvert at the waste transfer station would have a moderate benefit on threatened fish species from improving fish passage and allowing fish to access the stream channel in the project area.

A beaver dam downstream of the transfer station culvert was observed during the fall of 2007. The dam raised downstream water levels enough to increase the water depth in the culvert, which eliminated the outlet drop and provided sufficient water depth for fish passage. However, another beaver dam approximately 1½ feet high that was built across the culvert inlet was likely a complete barrier to all fish. A crossing on private agricultural land downstream of the transfer station is passable for adult anadromous and resident salmonids, but only provides suitable passage conditions for juvenile salmonids during some flows because juvenile fish cannot negotiate the excessive velocities within the culvert. The larger of the two pipes in the crossing acts as a velocity barrier at higher flows, but adult fish can pass through the smaller pipe.

Repeated removal of reed canary grass along about 0.6 miles of creek downstream of the project area and replacement of undersized culvert at the waste transfer station would affect threatened fish species downstream of the project area by improving water quality (increasing dissolved oxygen) and by improving the flow regime in the stream channel. These downstream restoration actions would have moderate long-term benefits by improving potential for fish passage to the upper reaches, including those in the project area. The long-term benefits to threatened fish and habitat in Strawberry Creek in the project area are dependent on these restoration actions in the downstream reaches outside the park boundary.

Conclusions: Effects on Threatened Fish

Short-term adverse effects on listed salmonids and their habitat from instream work and increased turbidity in the first few seasons following restoration activities would be minimized by application of measures required for projects funded through the CDFW FRGP and associated biological opinions issued by NMFS. The short-term adverse effects would be negligible to minor. In the unlikely event that fish are found in the wetland channels that would be excavated to remove non-native plants, short-term adverse effects on fish from dewatering and relocation would be mitigated through measures required for projects funded through the CDFW FRGP and the NOAA RC funding program, as described in the terms and conditions of the NOAA RC biological opinion, and the reasonable and prudent measures and the terms and conditions required under the biological opinion. A complete list of required measures to minimize adverse effects on listed fish species from projects funded under the CDFW FRGP and the NOAA RC program area found in the CDFW *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998, subsequent chapters and editions.)

Using the guidelines for project implementation outlined in the biological assessments and terms and conditions specified in associated NMFS biological opinions, cumulative adverse effects to anadromous fish or their habitat throughout the parks and in the region are expected to be minor and short-term. Long-term benefits to listed fish in the park are expected from the reduction of threats associated with erosion and sedimentation of streams resulting from failure of untreated roads and stream crossings, and from restoration of drainage patterns and geomorphic processes. All proposed restoration activities under the CDFW FRGP and the NOAA RC program are expected to result in adverse effects to listed species from dewatering streams, relocating fish, and increased sediment from instream activities. Dewatering, fish relocation, and structure placement would result in direct effects to listed salmonids, where a small percentage of individuals are expected to be killed or injured. The project is not expected to result in adverse effects from dewatering or fish relocation because no fish can currently reach the NPS area. The effects from increased sediment mobilization into streams are usually indirect effects, where the effects to habitat, individuals, or both, are reasonably certain to occur and are later in time. Stream flow diversion and project work area dewatering are expected to cause temporary loss, alteration, and reduction of aquatic habitat. Effects associated with dewatering, fish relocation, structure placement, and increased mobilization of sediment within stream channels are expected to be short-term and localized at each project site. NMFS has determined that these effects would be negligible to minor, because the temporal and spatial limits on work and the measures in place to minimize the effects. The cumulative long-term benefits of individual restoration projects would improve salmonid habitat conditions for multiple life-stages of salmon. Restored habitat from restoration projects should improve adult spawning success, juvenile survival, and smolt outmigration, which would in turn lead to improved abundance, productivity, spatial structure, and diversity within each watershed population.

The long-term effects on listed salmonids from the project to improve fish passage, restore portions of the watershed adjacent to the spawning streams, and reduce the threat of erosion would be beneficial and moderate. Replacement of the undersized culvert at the Humboldt County Waste Transfer Station would have a moderate benefit on threatened fish species from improving fish passage and allowing fish to access the stream channel in the project area.

NMFS determined that restoration activities conducted under the CDFW FRGP or NOAA RC program within NMFS Northern California Office are not likely to jeopardize the continued existence of the SONCC coho or NC steelhead. NMFS anticipates that incidental take of listed species as a result of projects authorized under these two programs will be in the form of harming or killing of fish during dewatering of streams and fish relocation, and temporary effects of sediment mobilization and modified hydrology during instream construction activities. Multiple fish and habitat protection measures, and the reasonable and prudent measures and the terms and conditions required under the NOAA RC/Corps funding and permitting for restoration activities would minimize the level and effect of take associated with the Strawberry Creek restoration project. Best management practices typically applied to park watershed restoration and road maintenance projects would further reduce the site-specific incidental take for listed fish.

NMFS determined that proposed restoration activities under both action alternatives are not likely to jeopardize the continued existence of SONCC coho salmon or NC steelhead; and are not likely to result in the destruction or adverse modification of designated critical habitat for these species. The non-discretionary reasonable and prudent measures and terms and conditions of the biological opinion, as well as two additional discretionary conservation measures, are expected to reduce the amount or extent of incidental take of SONCC coho salmon and NC steelhead. NMFS concluded that the proposed activities would adversely affect EFH for coho salmon, but that the activities would be conducted using adequate measures to avoid, minimize, mitigate, or otherwise offset the adverse effects to EFH.

Proposed restoration actions under both action alternatives may affect and are likely to adversely affect SONCC coho salmon and NC steelhead, and their designated critical habitat. However, the short term adverse effects will be outweighed by the long-term benefits to the species and their habitats from restoration of 1,600 feet of stream channels, replacement of undersized culverts with culverts large enough to convey 100-year flow events, and removal of four stream crossings in the upper Strawberry Creek watershed. The duration and magnitude of adverse effects to listed salmonids and designated critical habitat associated with project implementation would be significantly minimized due to the multiple avoidance and minimization measures found in the CDFW restoration manual and the reasonable and prudent measures and the terms and conditions required under the NMFS biological opinions.

EFFECTS ON CULTURAL RESOURCES

Methodology to Assess Effects—Potential impacts to historic properties either listed in or eligible to be listed in the National Register of Historic Places were identified and evaluated in accordance with the Advisory Council on Historic Preservation's regulations implementing Section 106 of the National Historic Preservation Act (36 CFR 800, *Protection of Historic Properties*): by (1) determining the area of potential effects; (2) identifying resources present in the area of potential effects that are listed in or eligible for the national register; (3) applying the criteria of adverse effect to affected resources; and (4) considering ways to avoid, minimize, or mitigate adverse effects.

Under the advisory council's regulations, a determination of *no historic properties affected*, *adverse effect,* or *no adverse effect* must be made for historic properties. A determination of *no historic properties affected* means that either there are no historic properties present, or there are historic properties present but the undertaking will have no effect upon them [36 CFR 800.4(d)(1)]. An *adverse effect* occurs whenever an impact alters, directly or indirectly, any characteristic of a cultural resource that qualifies it for inclusion in the national register, e.g. diminishing the integrity (or the extent to which a resource retains its historic appearance) of its location, design, setting, materials, workmanship, feeling, or association. Adverse effects also include reasonably foreseeable effects caused by the alternatives that would occur later in time, be farther removed in distance, or be cumulative [36 CFR 800.5(a) (1)]. A determination of *no adverse effect* means there is an effect, but the effect would not meet the criteria of an adverse effect, i.e. diminish the characteristics of the cultural resource that qualify it for inclusion in the national register [36 CFR 800.5(b)].

Thus, the criteria for characterizing the severity or intensity of impacts to national register-listed or -eligible archeological resources, prehistoric or historic structures, cultural landscapes, and traditional cultural properties are the Section 106 determinations of effect: *no historic properties affected*, *adverse effect*, or *no adverse effect*. A Section 106 determination of effect is included in the conclusion section for each analysis of impacts to national register-listed or -eligible cultural resources.

No national register-eligible cultural resources are present in the project area. There is an exceedingly low possibility that buried archeological deposits are present in the project area.

Effects on Archeological Resources under the No-action Alternative
Under the no-action alternative, the NPS would perform minimal maintenance of the existing culverts by periodically removing accumulated debris. In addition, culverts would be replaced when they wear out or when they no longer function to convey water beneath the SOC Road. Since this work would result in ground disturbance with the exceedingly low probability of encountering buried archeological deposits, effects to archeological resources would be potentially minor and adverse.

In order to reduce potential minor short-term adverse effects to archeological resources, the NPS recommends the following protection measures for this unlikely event:

- Monitors will be on site during all excavations associated with culvert replacement. Monitors will consist of an archeologist meeting the secretary of the interior’s standards, and a trained Yurok tribal monitor. Monitors will be needed during all initial ground disturbance. Monitoring for secondary disturbance will occur periodically or as needed.
- In the unlikely event that that previously undocumented archeological resources including but not limited to flaked stone artifacts (arrowheads or flakes), shellfish, bone, deposits of old bottles and cans, unusual soil deposits, or wooden structural debris is encountered during project implementation, work in that location will be immediately suspended until an archeologist meeting the secretary of the interior’s standards has evaluated the find. No artifacts will be collected, and everything will be left in-situ until the NPS cultural resource specialists, the Yurok THPO, the Yurok Native American Graves Protection and Repatriation Act (NAGPRA) director, and the California SHPO are contacted to determine how best to proceed in accordance with 36 CFR 800.
- In the event that human remains are encountered, all work in the immediate vicinity will be immediately suspended until the origins of the remains can be determined as modern, historic, or prehistoric. Remains will be left in-situ unless it is absolutely necessary to remove them. Staff will work with NPS park rangers, coroners, tribal specialists, and forensic anthropologists as needed to provide the necessary protections to the remains. If found applicable, the NPS would then follow the NAGPRA regulations (43 CFR 10).

There would be no effect to historic structures or cultural landscapes from the no-action alternative.

There would be potential minor long-term adverse effects to ethnographic resources since the Yurok Tribe ascribes significance to both the cultural and natural resource values of the Strawberry Creek ecosystem, which would not be restored as part of the no-action alternative.

Effects on Archeological Resources under Action Alternatives
Because both the proposed action (Alternative 2) and Alternative 3 involve extensive ground disturbance, there is a possibility of buried archeological deposits being encountered during project implementation. Although this possibility of buried archeological deposits is considered to be low, there could be minor, short term adverse effects to buried archeological resources that have not been detected in surveys.

In order to reduce potential minor short term adverse effects to buried archeological resources, the NPS recommends the same protection measures for this unlikely event that were described above under no-action.

There would be no effect to historic structures from the proposed action (Alternative 2) or Alternative 3. The Antonioli Ranch and its associated structures were determined ineligible for listing in the national register. There would be no effect to cultural landscapes under the proposed action or Alternative 3.

The NPS consulted with the Yurok Tribe's culture committee on February 27, 2009 regarding the project location and on December 17, 2010 about the proposed geotechnical test pits and auger testing. The committee asked questions about the purpose of the study and why the existing creek wasn't good enough for fish. It was explained that the current channel does not have the physical characteristics that fish need including the right meander, in-stream structures, shade and substrate, and that the NPS proposed project would be a heavily engineered design, but it would restore fish habitat. Further, NPS staff indicated to the committee that final design plans would be shared with the THPO. The committee again supported the project as being consistent with Yurok values, and no additional cultural concerns were raised about the project or project location.

Under both action alternatives to restore portions of the Strawberry Creek ecosystem, there would be minor long-term beneficial effects to ethnographic resources significant to the Yurok Tribe who ascribes importance to the cultural and natural resource values associated with the entire Strawberry Creek ecosystem. Consultation with the Yurok THPO and the Yurok Tribe's culture committee indicates restoration of Strawberry Creek is consistent with Yurok values.

Cumulative Effects on Archeological Resources
Cultural resources investigations were conducted for projects downstream of the NPS project area (Salisbury and Burns 2010).

An amendment to the 2010 study (Rich 2013a, b) documented a second investigation of the project area conducted during the summer of 2012 to reinvestigate the areas within the final design limits of the proposed downstream actions. No historic resources meeting the criteria of the California Register of Historic Resources or eligible for listing in the National Register of Historic Places were identified during either of these studies.

Since no historic properties have been documented in the project area, there would be no cumulative effects to cultural resources from the proposed action or alternatives, including the no-action alternative. Cultural resources throughout the remainder of the park would not be affected under any of the alternatives.

In the unlikely event that buried archeological resources are encountered during ground disturbance, adverse effects would be highly localized and minimized by the protection measures described above under no-action.

Conclusions: Effects on Archeological Resources.
Although deeply buried archeological resources may occur in the Strawberry Creek project area, it is expected that this possibility is exceedingly low. The potential for effects under either the proposed action or Alternative 3 would be highly localized. These potential adverse effects would not be considered severe because protection measures are in place to address this unlikely occurrence.

The NPS submitted a determination of "No Historic Properties Affected" from the proposed action to the California state historic preservation officer (SHPO) on November 21, 2013, in accordance with 36 CFR 800.5. The SHPO concurred with the NPS determination in a letter dated December 23, 2013 (reference NPS100125A).

EFFECTS ON VISITORS AND VISITOR EXPERIENCE

Visitor use in the project area is very limited because it is behind a locked gate and is not signed or advertised as a visitor use area in park informational media. Visitors have been observed in the project area viewing wildlife, mostly birds, along SOC Road. Under the no-action alternative, there would be no direct effects on visitors. Under the proposed action (Alternative 2) and the more extensive restoration alternative (Alternative 3), there would be short-term adverse effects on those visitors who might want to access the project area when it is closed for construction. Under both the proposed action (Alternative 2) and the more extensive restoration alternative (Alternative 3), there would be long-term benefits from the opportunity to educate and inform park visitors about efforts to improve fish habitat in the park. After project implementation, park resource management and interpretive staff expect that there would be opportunities for interpretive and educational programs about the Strawberry Creek restoration project.

EFFECTS ON PARK OPERATIONS

Under the no-action alternative, there would be no project-related effects on park operations or uses at the administrative area, including access to the ranger residence. SOC Road would continue to require occasional grading and brushing to maintain access to the administrative area. If the culverts on SOC Road fail catastrophically, the road would be closed until the culverts are replaced.

Under both action alternatives, access to the administrative area and ranger residence would be provided with a temporary access road that bypasses the West Tributary culvert during construction to replace the culvert. There may be very short delays on SOC Road when heavy equipment is working to construct the temporary access road. Other project related-work such as mobilization of heavy equipment may require temporary delays.

After coho and steelhead occupy the restored stream, road maintenance activities that might result in erosion and runoff into the stream would require Best Management Practices (BMPs) in compliance with the Terms and Conditions in the NMFS BO for routine road maintenance projects in RNSP (NMFS File No. 151422SWR2005AR00575; Holden 2005; NMFS 2008). These BMPs generally involve seasonal restrictions similar to those required for the proposed project (work during low-flow periods, erosion control measures, etc.).

Under both action alternatives, about three years of maintenance on the newly planted areas is expected to be needed to replace trees that die and to handpull reed canary grass that resprouts.

EFFECTS ON SOCIOECONOMICS

Creation of a channel to convey stream flows is expected to reduce flooding on the pasturelands downstream of the project areas. Reducing overbank flooding on the privately owned grazing lands adjacent to the park is a moderate benefit for landowners.

GROWTH-INDUCING IMPACTS

None of the alternatives, including the proposed action, would result in increased growth of the community of Orick or vicinity. The project would not result in an increase in visitation to the park.

PUBLIC INVOLVEMENT, COORDINATION, AND CONSULTATION

PUBLIC INVOLVEMENT

The Redwood Creek Watershed Group has met regularly since 2005 to discuss issues related to management of Redwood Creek watershed. The group is updated on the status of restoration activities being conducted in the Strawberry Creek watershed. RCWG meetings are regularly attended by representatives from CalTrout, CDFW, Humboldt County, Orick Community Services District, PCFWWRA, NMFS, and local private landowners. Other attendees present when Strawberry Creek restoration has been discussed include representatives of elected officials, federal and state land and resource management agencies, and local private corporations and businesses that operate in the Redwood Creek watershed.

The NPS gave a brief presentation on September 6, 2012 on the proposed Strawberry Creek restoration to the Pacific Fisheries Legislative Task Force comprised of state elected officials from Alaska, Idaho, Washington, Oregon, and California.

This project is part of a collaborative approach to management of the Redwood Creek watershed among federal, state, and local agencies, conservation organizations, and private landowners. These groups have been informed about the Strawberry Creek restoration project since 2006 and have expressed support for this project.

Public comment received on the watershed restoration proposal in the 1999 GMP/EIS; the 2006 Lost Man Creek watershed restoration project; the 2008 North Fork Streelow Creek culvert-to-bridge project; the 2009 North Fork Lost Man Creek culvert-to-bridge project; the 2010 Streelow Creek road-to-trail conversion; and other similar projects in the region directed at restoration of salmonid habitat indicates broad public support for such projects.

RECIPIENTS OF THE ENVIRONMENTAL ASSESSMENT

The EA, or a letter announcing its availability, has been made available or sent to local and regional offices of federal and state agencies, affected American Indian tribes, and local organizations listed below, in addition to individuals who have expressed an interest in similar park projects. Copies are available in local libraries, at park offices, and on the Internet on the NPS planning website (parkplanning.nps.gov/redw/StrawberryCreek). The park has also issued a news release to its standard mailing list.

Federal Agencies
Bureau of Indian Affairs, Pacific Regional Office, Sacramento CA
Bureau of Land Management, Arcata Resource Area, Arcata CA
National Park Service, Pacific West Region, San Francisco CA

National Park Service, Water Resources Division, Fort Collins CO
U.S. Army Corps of Engineers, San Francisco District
U.S. Department of Agriculture, Forest Service, Six Rivers National Forest
U.S. Department of Commerce, NOAA Fisheries, NMFS California Coastal Area Office, Arcata CA
U.S. Environmental Protection Agency, Region 9, San Francisco CA
U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata CA

United States Representatives
Congressman Jared Huffman (CA 2nd District)

State Agencies
California Department of Fish and Wildlife, Eureka CA
California Department of Fish and Wildlife, Sacramento CA
California Office of Historic Preservation, Sacramento CA
California Wildlife Conservation Board, Sacramento CA
North Coast Regional Water Quality Control Board, Santa Rosa CA
North Coast Unified Air Quality District, Eureka CA
State Coastal Conservancy, Oakland CA

State Representatives
Assemblyman Wesley Chesbro
Joint Committee on Fisheries and Agriculture (T. Weseloh)

American Indian Tribes
Big Lagoon Rancheria
Resighini Rancheria
Trinidad Rancheria
Yurok Tribe

County and Local Governments
City of Arcata
Del Norte County Board of Supervisors
Humboldt County Board of Supervisors
Orick Community Services District

Organizations and Businesses
California Native Plant Society
CalTrout
Crescent City-Del Norte Chamber of Commerce
Environmental Protection Information Center
Environmental Restoration Services
Eureka Chamber of Commerce
Friends of Del Norte
Mattole Restoration Council
National Parks Conservation Association

Northcoast Environmental Center
Northcoast Regional Land Trust
Orick Chamber of Commerce
Pacific Coast Fish, Wildlife, and Wetlands Restoration Association
Pacific Watershed Associates
Redwood Community Action Agency
Redwood Creek Watershed Group
Redwood Parks Association
Save-the-Redwoods League
Sierra Club North Group
Siskiyou Project
Smith River Alliance
Stillwater Sciences
The Nature Conservancy

<u>Universities</u>
California State University, Humboldt
Cooperative Fish and Wildlife Research Unit, Humboldt State University, Arcata CA

<u>Libraries</u>
Del Norte County Public Library
Humboldt County Public Library and branches
Humboldt State University Library

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- Joel Wagner, Wetland Program Leader, Natural Resources Program Center, Denver, CO (wetland delineation)

ABBREVIATIONS AND ACRONYMS

ac	acres
ACOE	Army Corps of Engineers
APE	Area of potential effect
BO	Biological Opinion
BMP	Best Management Practices
CASQA	California Stormwater Quality Association
CCC	Civilian Conservation Corps
CC Chinook	California Coastal Chinook salmon
CESA	California Endangered Species Act
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CRAM	California Rapid Assessment Method
CDFW	California Department of Fish and Wildlife
CWMW	California Wetlands Monitoring Workgroup
CFR	Code of Federal Regulations
cfs	cubic feet per second
cu yd	cubic yards
CSZ	Cascadia Subduction Zone
dbh	diameter at breast height
EA	Environment Assessment
EFH	Essential Fish Habitat
EO	Executive Order
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FRGP	Fisheries Restoration Grant Program
FSOF	Floodplain State of Findings
FWS	[US] Fish and Wildlife Service
ft	feet
GHG	Greenhouse gas
GIS	Geographic Information System
GMP/GP FEIS/R	General Management Plan/General Plan Final Environmental Impact Statement/Report
HSU CRF	Humboldt State University Cultural Resources Facility
ICT	Interagency Consultation Team
LCS	List of Classified Structures
lf	linear feet
mi	miles
mg/l	milligrams per liter
NAVD88	North American Vertical Datum of 1988
NC Steelhead	Northern California (steelhead)
NCRWQCB	North Coast Regional Water Quality Control Board
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service

NOAA	National Oceanographic and Atmospheric Administration
NOAA RC	National Oceanographic and Atmospheric Administration Restoration Center
NPS	National Park Service
NTU	nephelometric turbidity units
PCE	Primary constituent elements
PCFWWRA	Pacific Coast Fish, Wildlife and Wetland Restoration Association
$PM_{2.5}$	particulate matter less than 2.5 micrometers in diameter
PM_{10}	particulate matter less than 10 micrometers in diameter
RCWG	Redwood Creek Watershed Group
RNSP	Redwood National and State Parks
Section 7	Section 7 of the Endangered Species Act of 1973, as amended
SOC	South Operations Center
SONCC coho	Southern Oregon/Northern California Coast (SONCC) coho salmon
sq ft	square feet
TMDL	Total Maximum Daily Load
USC	United States Code
USDA-NRCS	United States Department of Agriculture-Natural Resource Conservation Service
USDC	United States Department of Commerce
USFWS	United States Fish and Wildlife Service
WSOS	Wetlands Statement of Findings
WT	West Tributary
µS	specific conductance
°C	degrees centigrade or Celsius
°F	degrees Fahrenheit
106	Section 106 of the National Historic Preservation Act
401	Section 401 of the Clean Water Act
404	Section 404 of the Clean Water Act

<u>Abbreviations used in Figures A-1 through A-18</u>

approx	Approximately
CL	Centerline
Conc	Concrete
CMP	Corrugated Metal Pipe
CMPA	Corrugated Metal Pipe Arch
OHD	Overhead Power
DIA	Diameter
(E)	Existing
ELEV	elevation
FT	Feet
FL	Flow line
(X:1)	Horizontal : Vertical
IN	Inches
EG	Existing Ground

FG	Finished Ground
LOD	Limits of Disturbance
Max	Maximum
Min	Minimum
(N)	New
NTS	Not to Scale
O.C.	On Center
O.D.	Outside Diameter
RSP	Rock Slope Protection
STA	Station
TYP	Typical
TBD	To Be Determined
W/	With
1+00	Alignment of construction stations in hundreds of feet

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APPENDICES

Appendix A: Alternatives Drawings and Figures

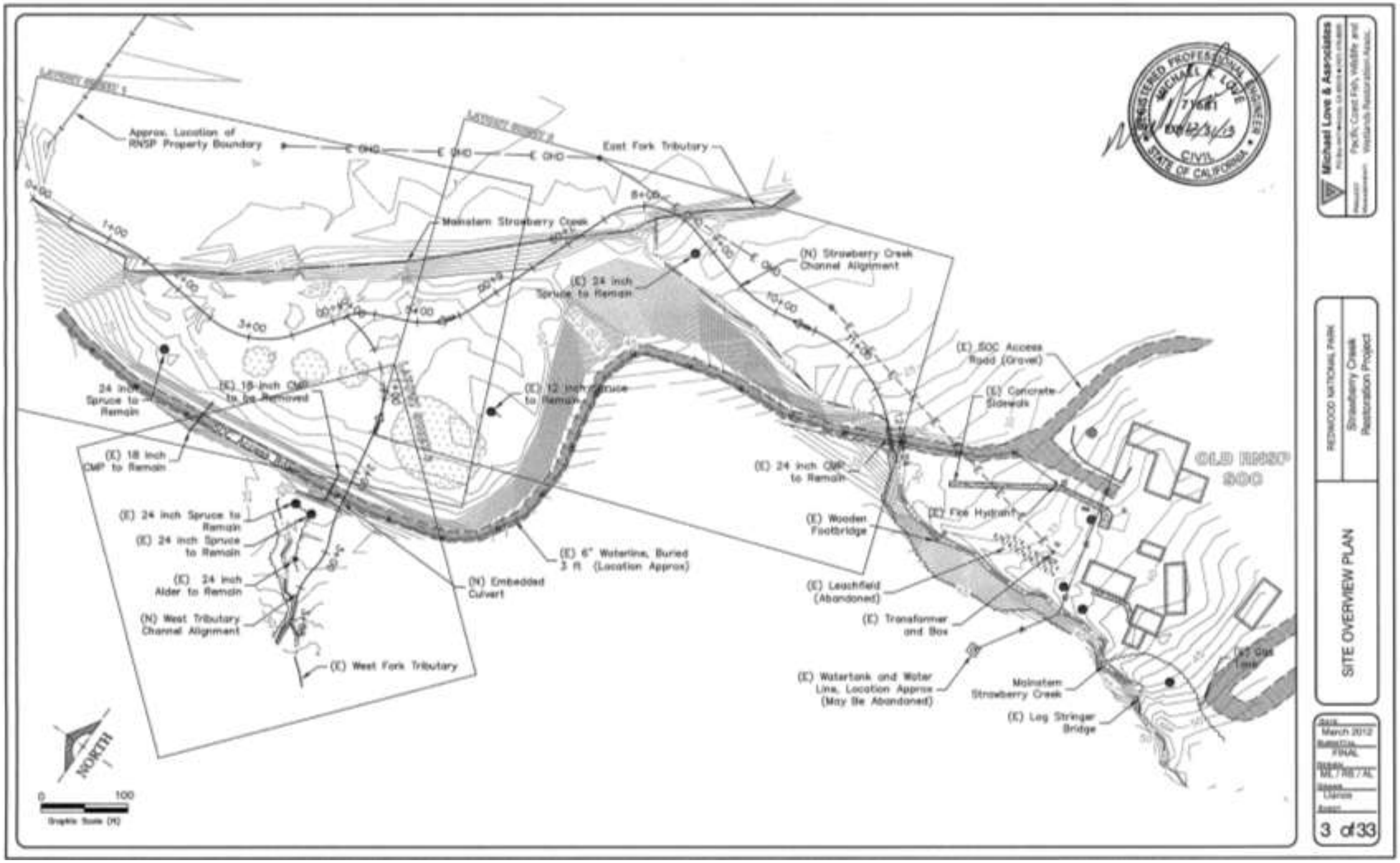


Figure A-1: No-action alternative, existing conditions (includes proposed constructed channel alignment for Alternative 2) (from Love and Shea 2012)

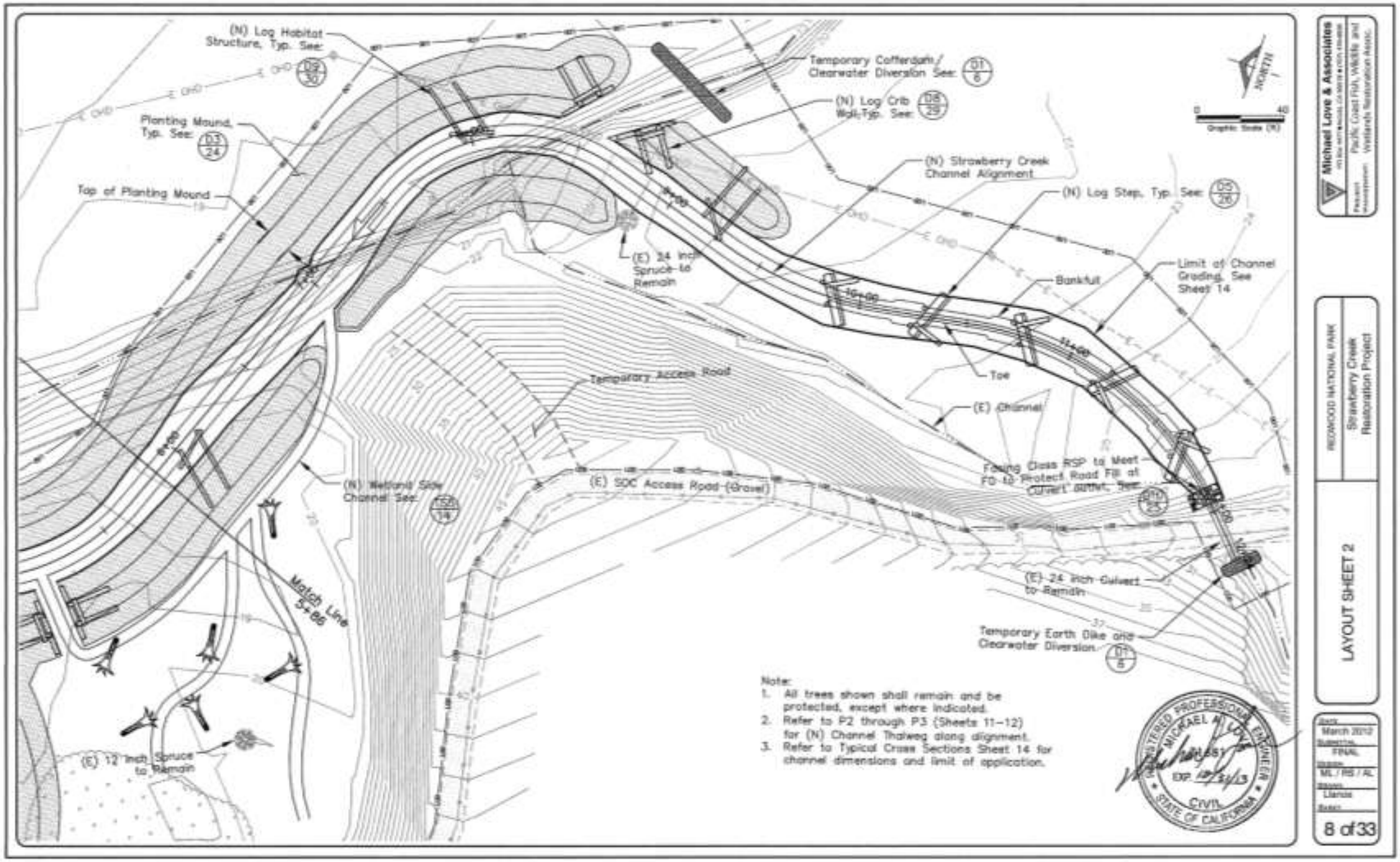


Figure A-2: Alternative 2 (proposed action) upstream reach (from Love and Shea 2012)

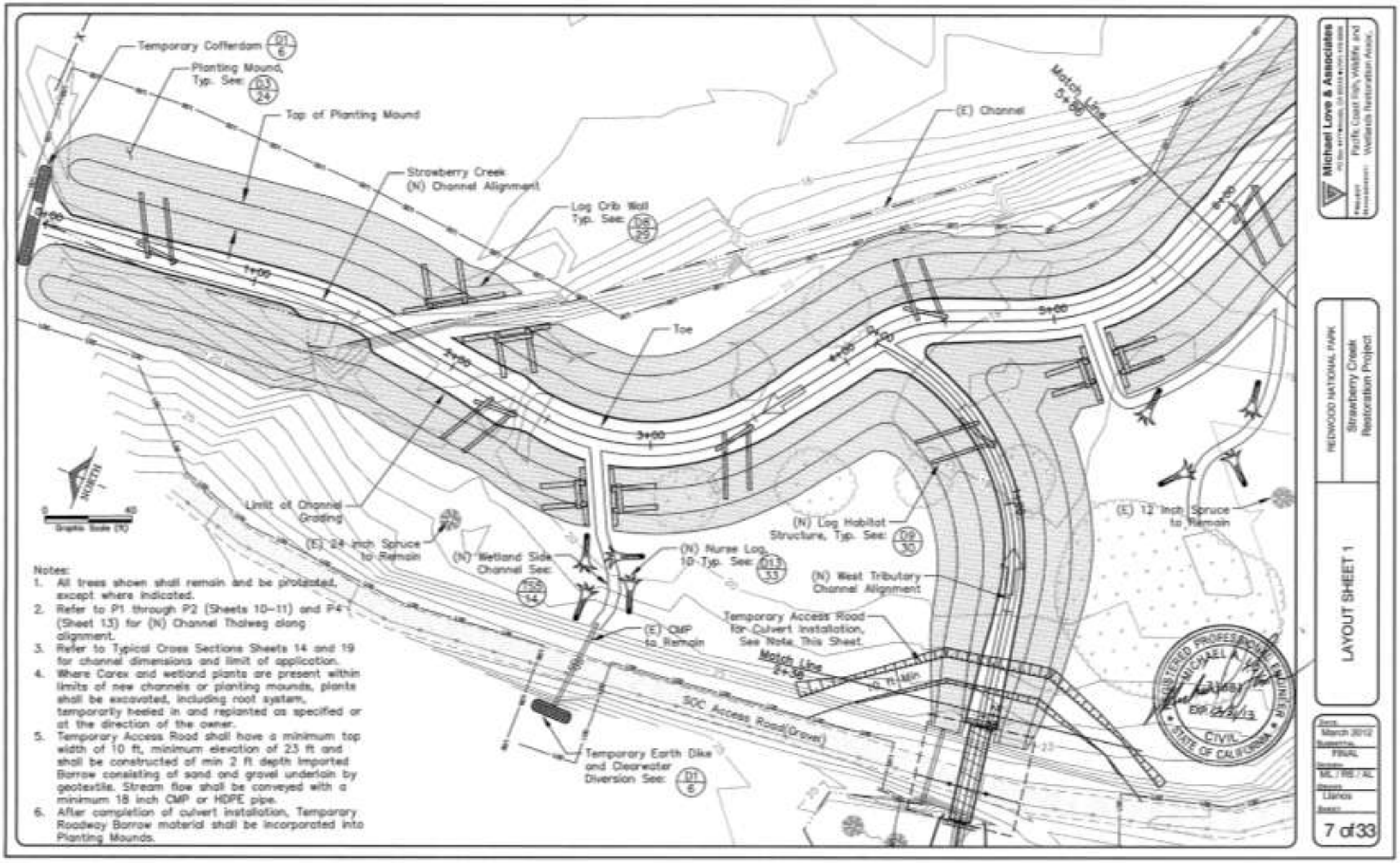


Figure A-3: Alternative 2, downstream reach (from Love and Shea 2012)

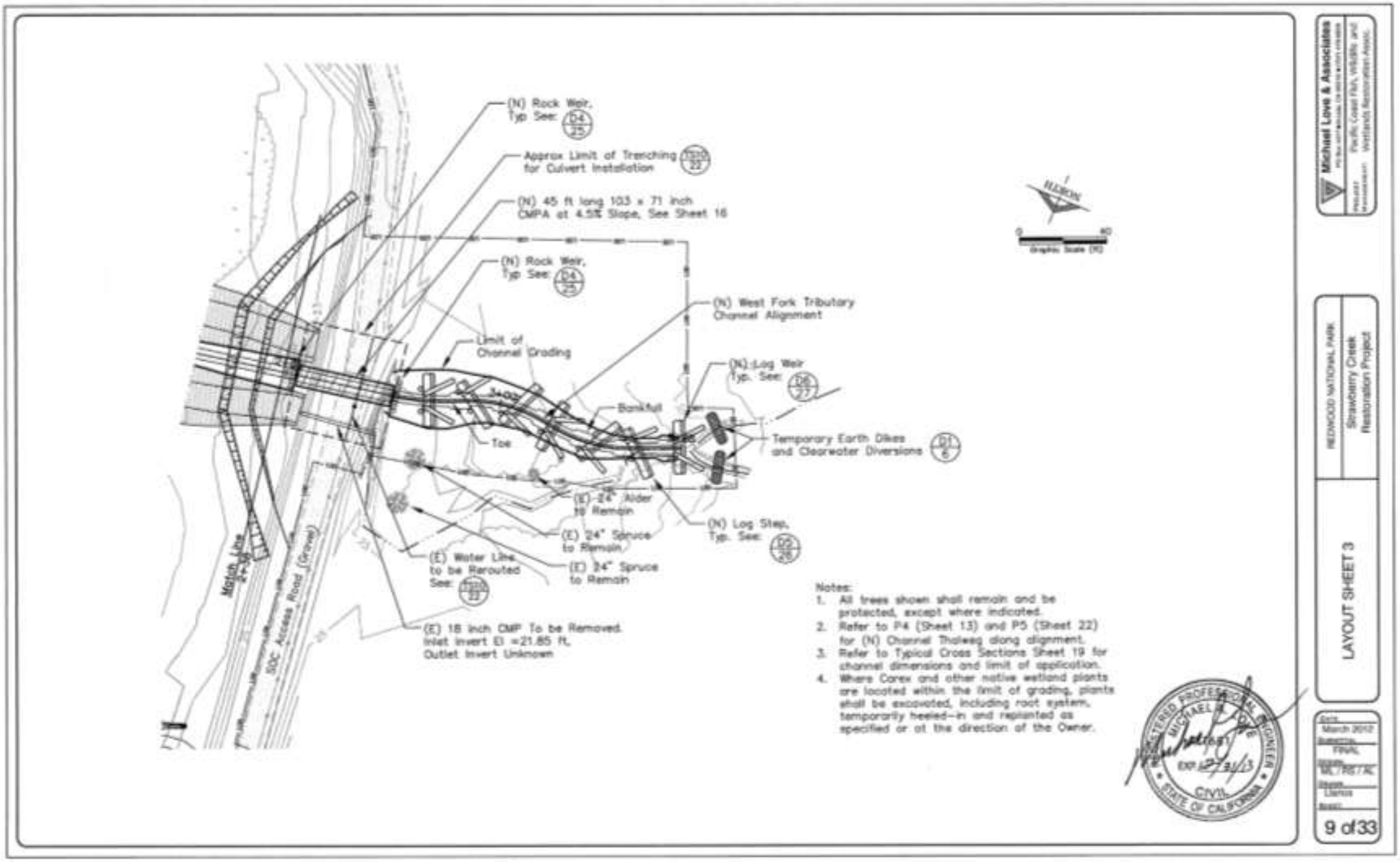


Figure A-4: Alternative 2 (proposed action) upper West Tributary reach (from Love and Shea 2012)

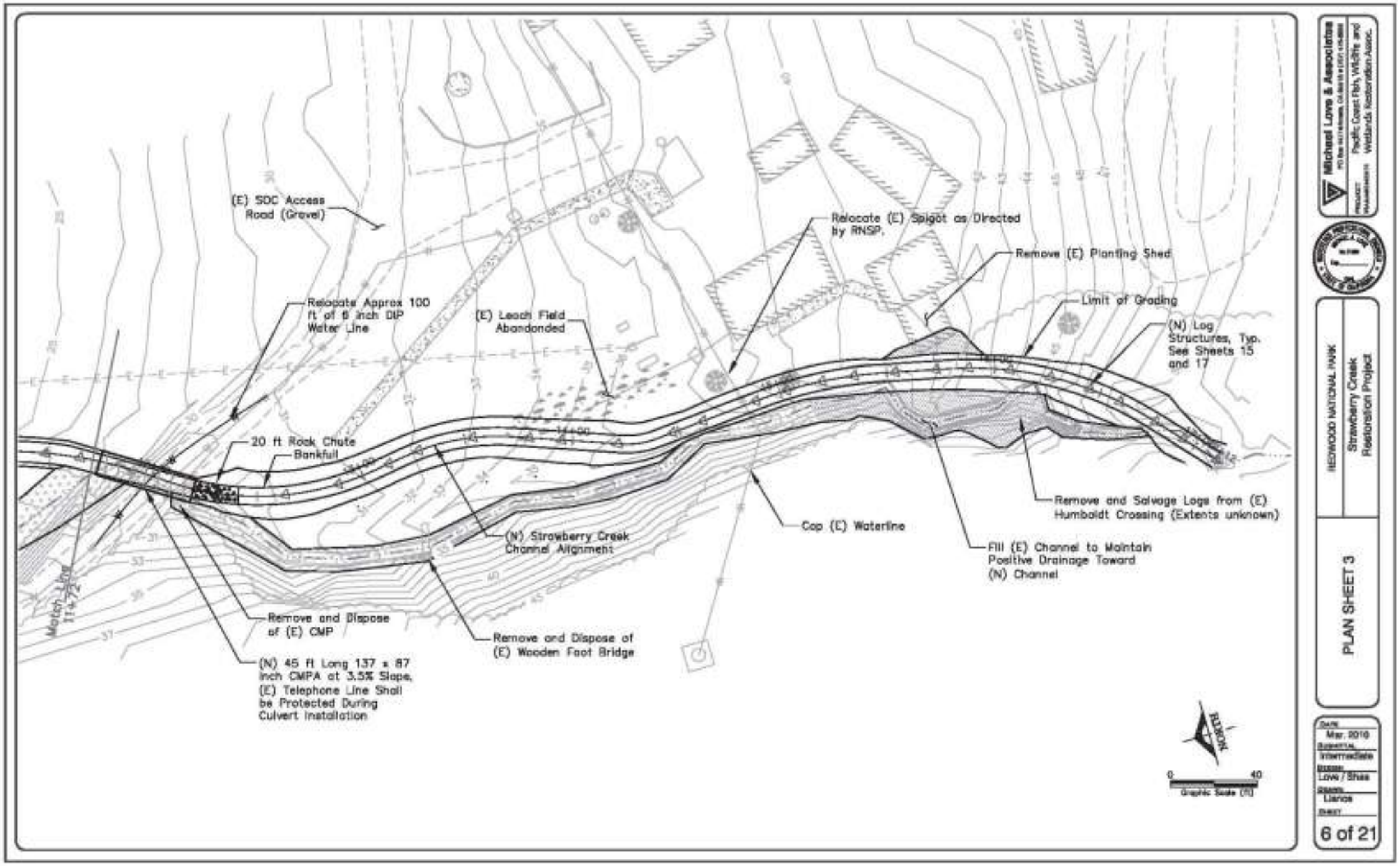


Figure A-5: Alternative 3, upper SOC Tributary reach (adapted from Love and Shea 2010)

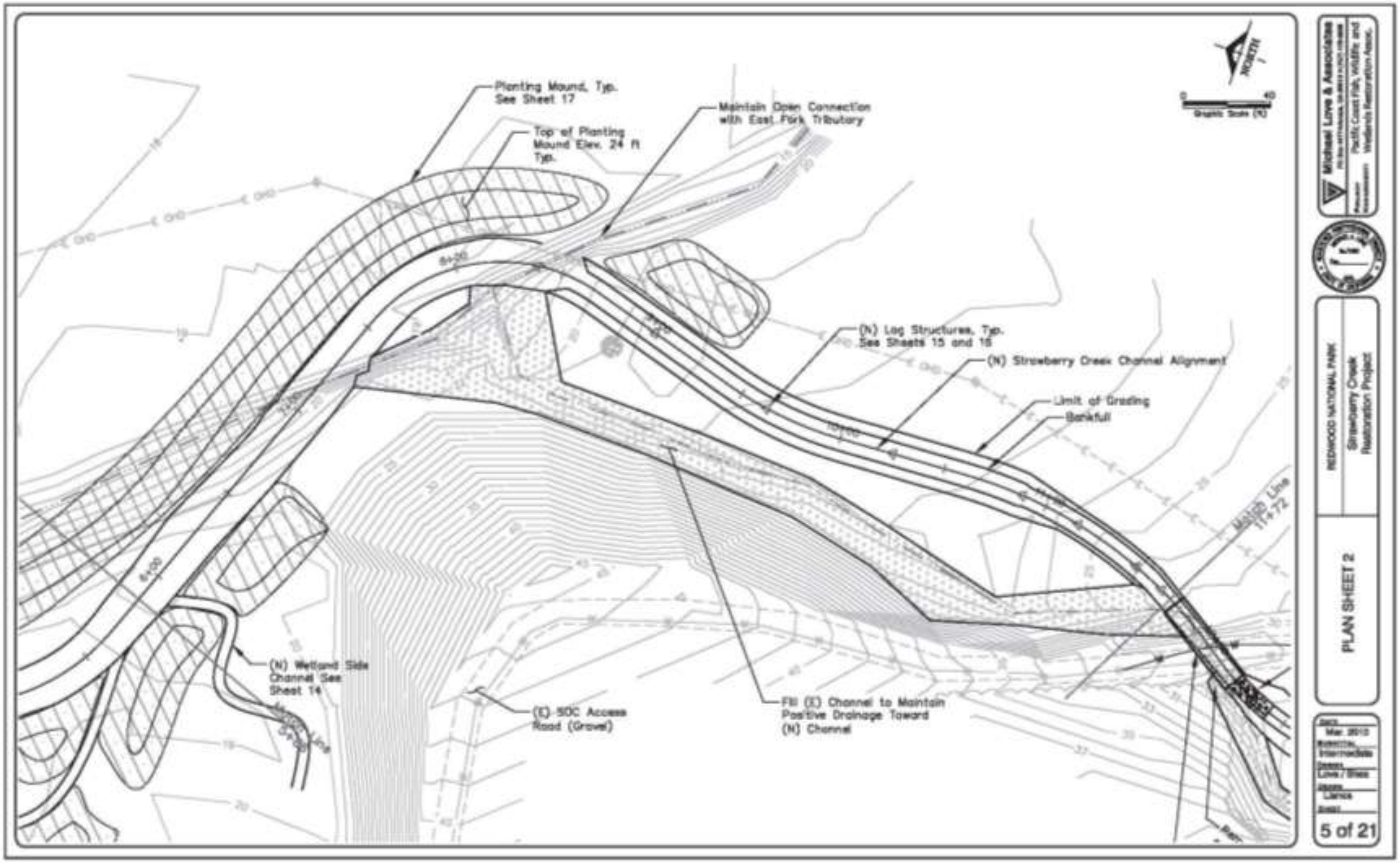


Figure A-6: Alternative 3, upstream reach (adapted from Love and Shea 2010)

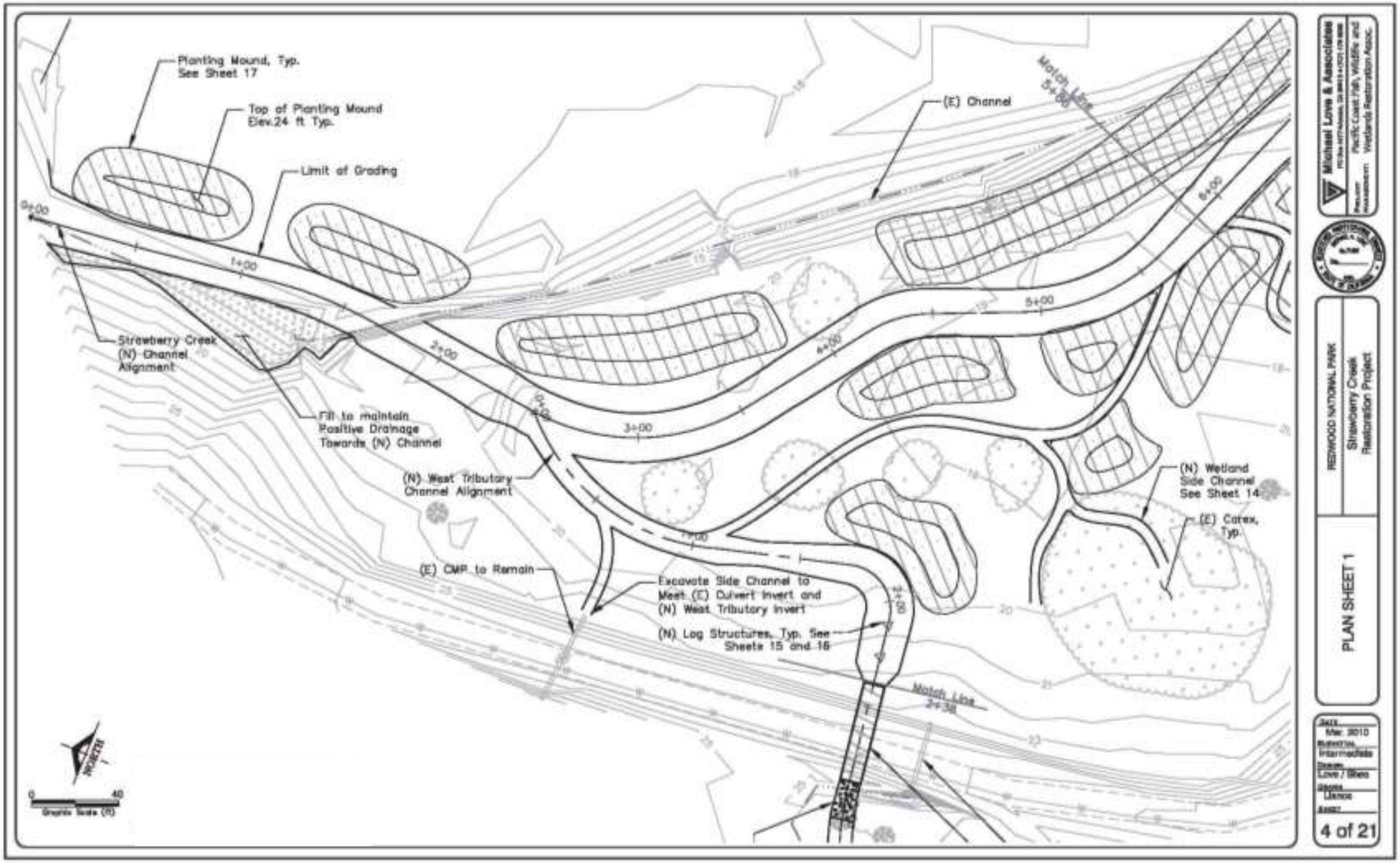


Figure A-7: Alternative 3, downstream reach (adapted from Love and Shea 2010)

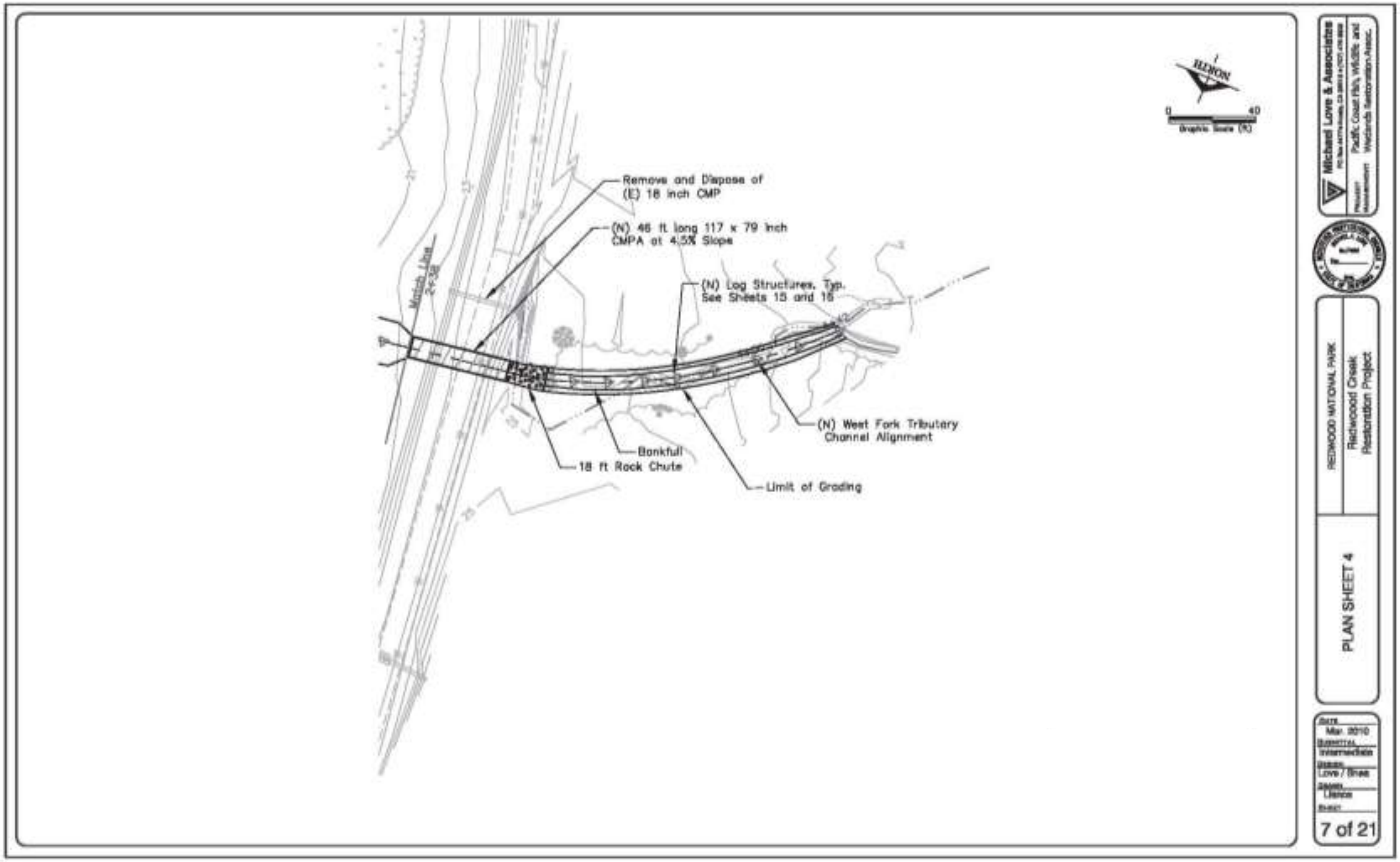


Figure A-8: Alternative 3, West Tributary (adapted from Love and Shea 2010)

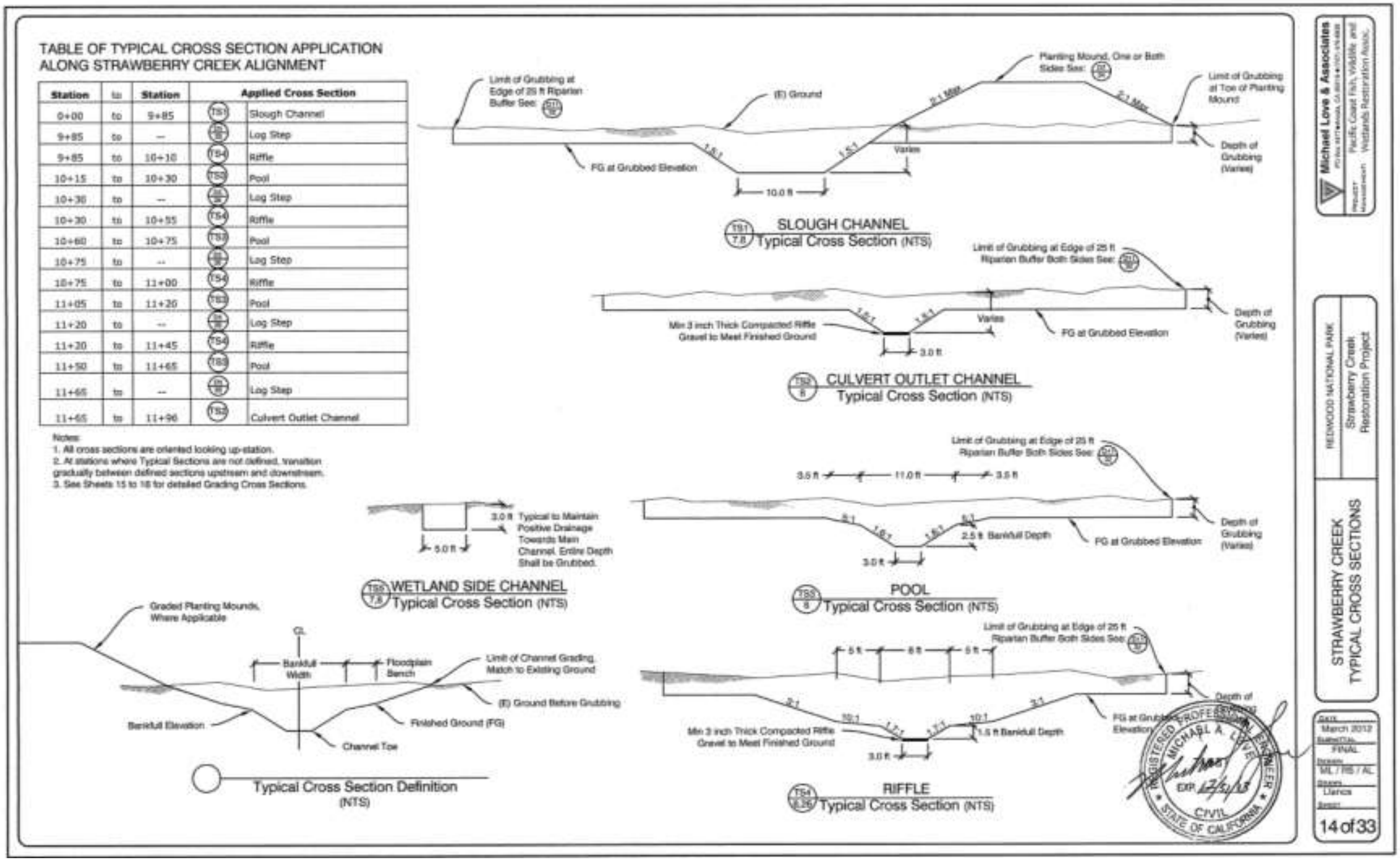
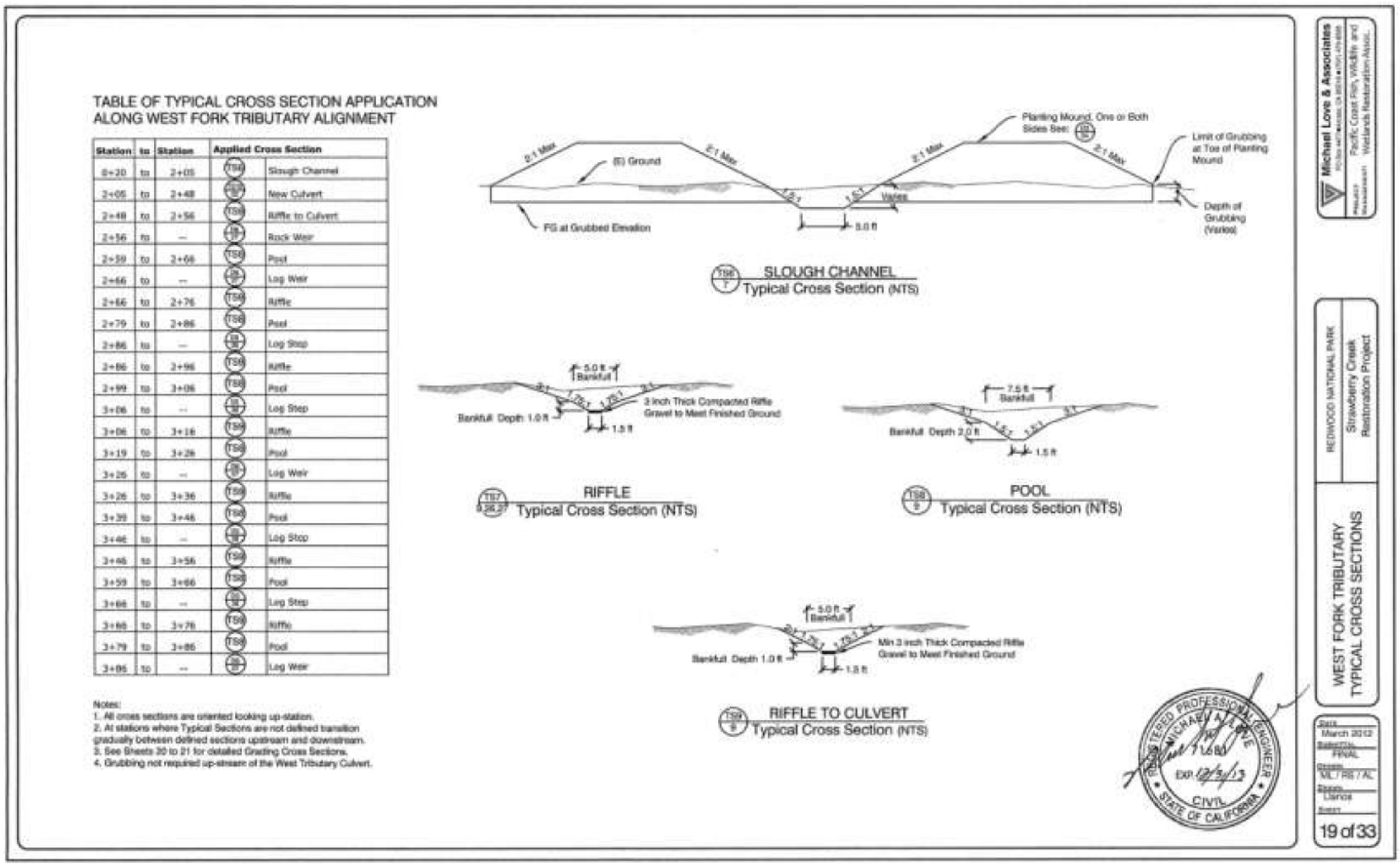


Figure A-9: Alternative 2 (proposed action) and Alternative 3—main channel cross sections (from Love and Shea 2012)



Station	to	Station	Applied Cross Section	
0+20	to	2+05	[illegible]	Slough Channel
2+05	to	2+48	[illegible]	New Culvert
2+48	to	2+56	[illegible]	Riffle to Culvert
2+56	to	--	[illegible]	Rock Weir
2+59	to	2+66	[illegible]	Pool
2+66	to	--	[illegible]	Log Weir
2+66	to	2+76	[illegible]	Riffle
2+79	to	2+86	[illegible]	Pool
2+86	to	--	[illegible]	Log Step
2+86	to	2+96	[illegible]	Riffle
2+99	to	3+06	[illegible]	Pool
3+06	to	--	[illegible]	Log Step
3+06	to	3+16	[illegible]	Riffle
3+19	to	3+26	[illegible]	Pool
3+26	to	--	[illegible]	Log Weir
3+26	to	3+36	[illegible]	Riffle
3+39	to	3+46	[illegible]	Pool
3+46	to	--	[illegible]	Log Step
3+46	to	3+56	[illegible]	Riffle
3+59	to	3+66	[illegible]	Pool
3+66	to	--	[illegible]	Log Step
3+66	to	3+76	[illegible]	Riffle
3+79	to	3+86	[illegible]	Pool
3+86	to	--	[illegible]	Log Weir

Figure A-10: Alternative 2 (proposed action) and Alternative 3—West Tributary cross sections (from Love and Shea 2012)

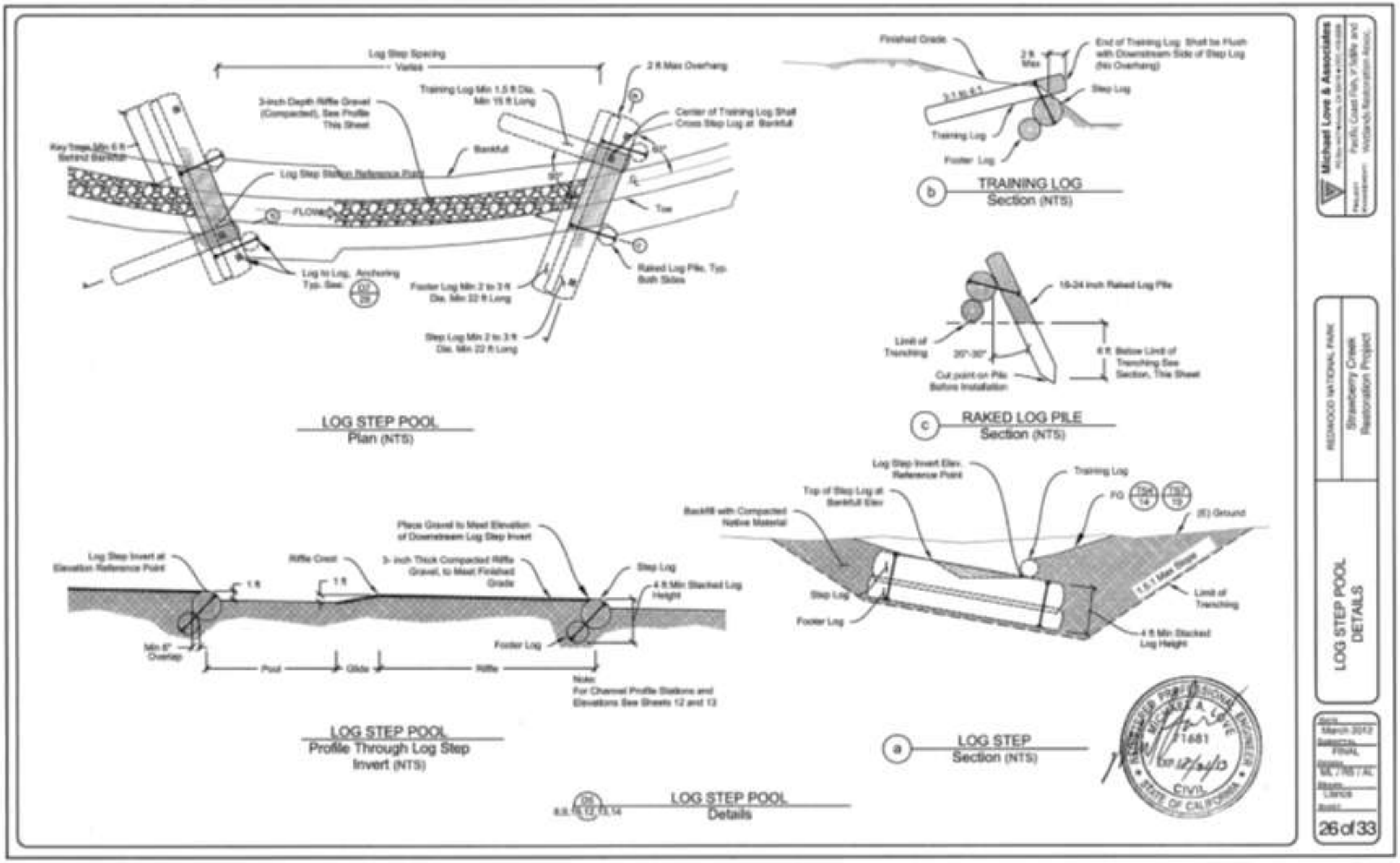


Figure A-11: Alternative 2 (proposed action) and Alternative 3—log steps and log pools (from Love and Shea 2012)

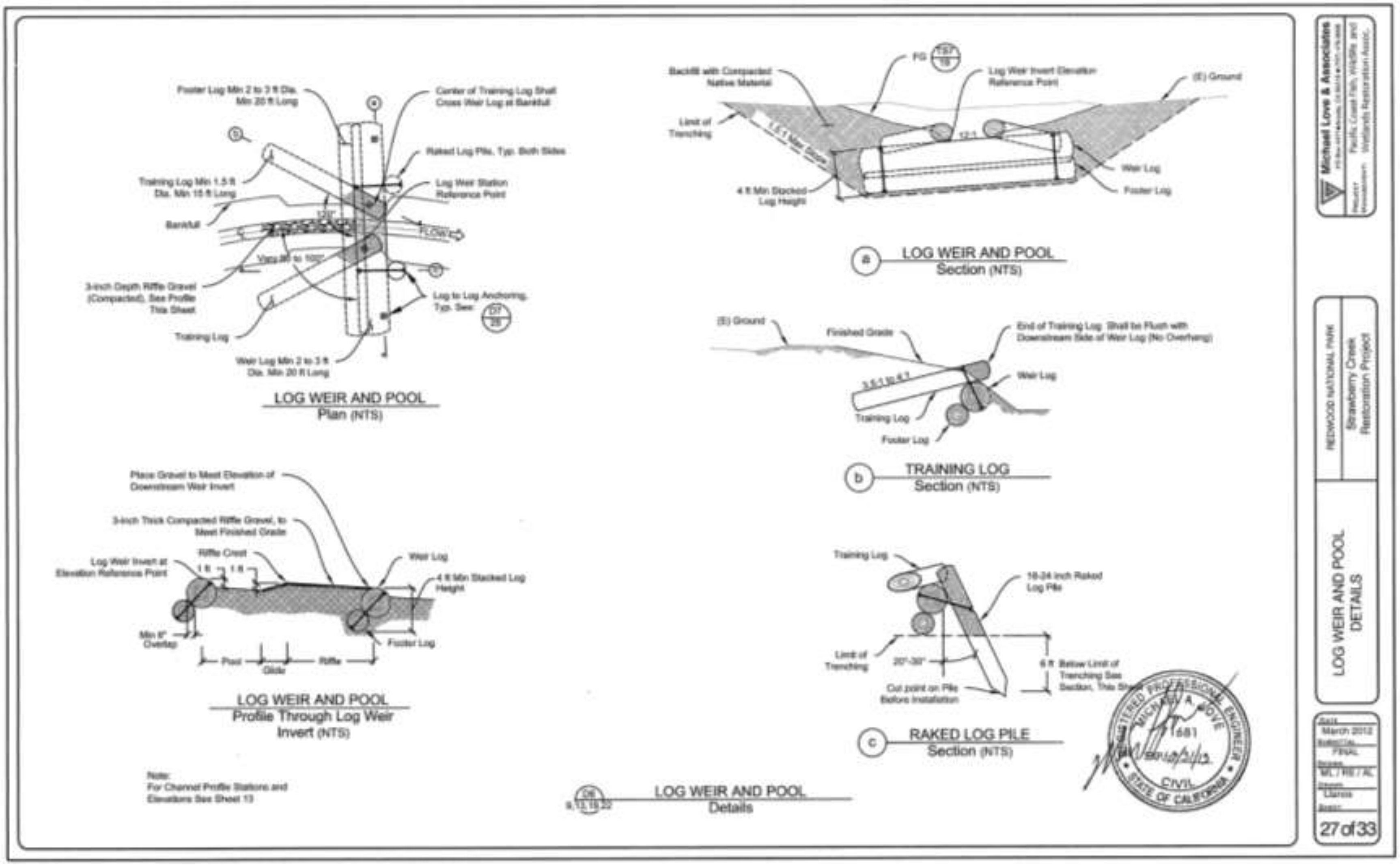


Figure A-12: Alternative 2 (proposed action) and Alternative 3—log weirs (from Love and Shea 2012)

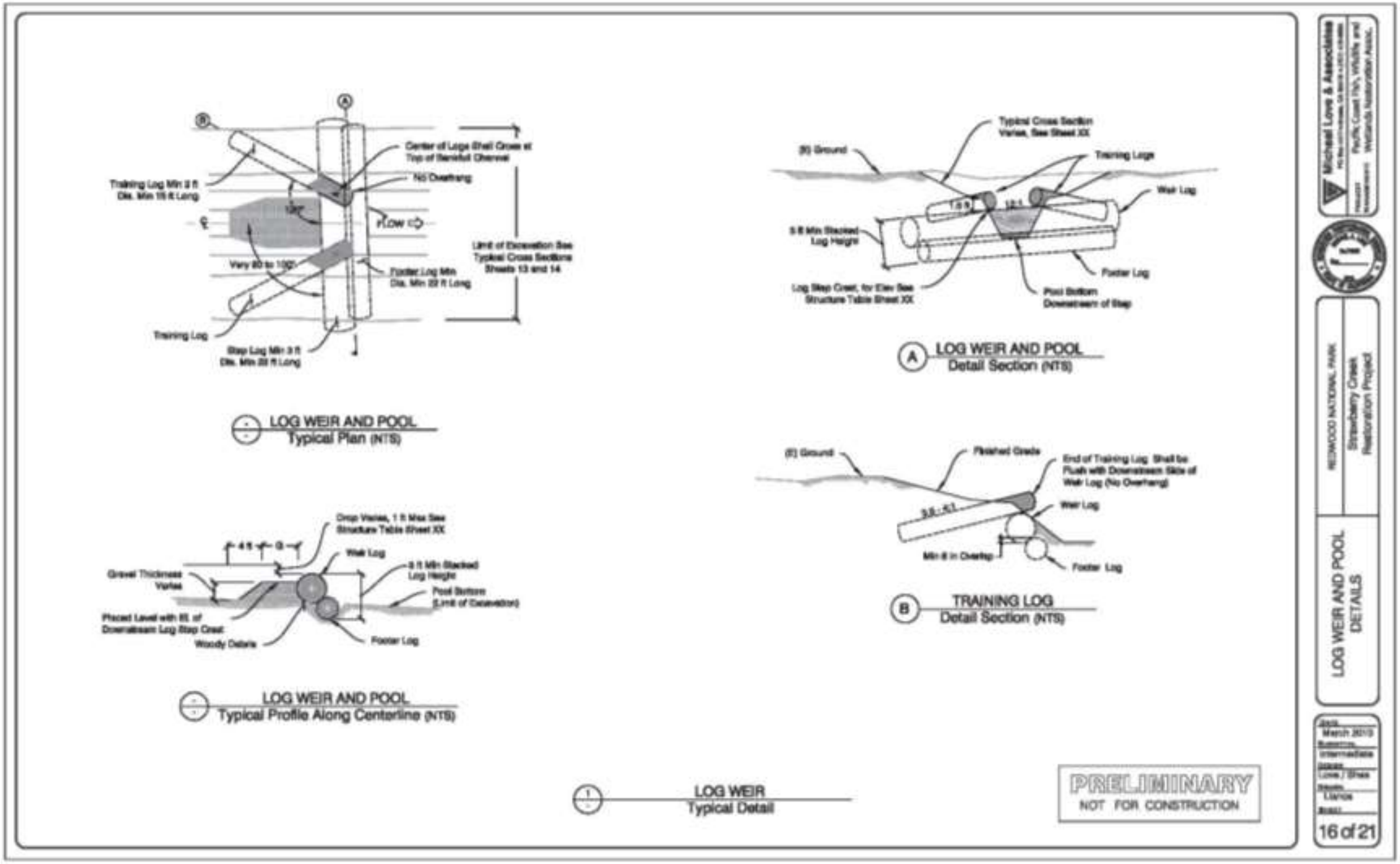


Figure A-13: Alternative 3—log weirs and log pools (adapted from Love and Shea 2010)

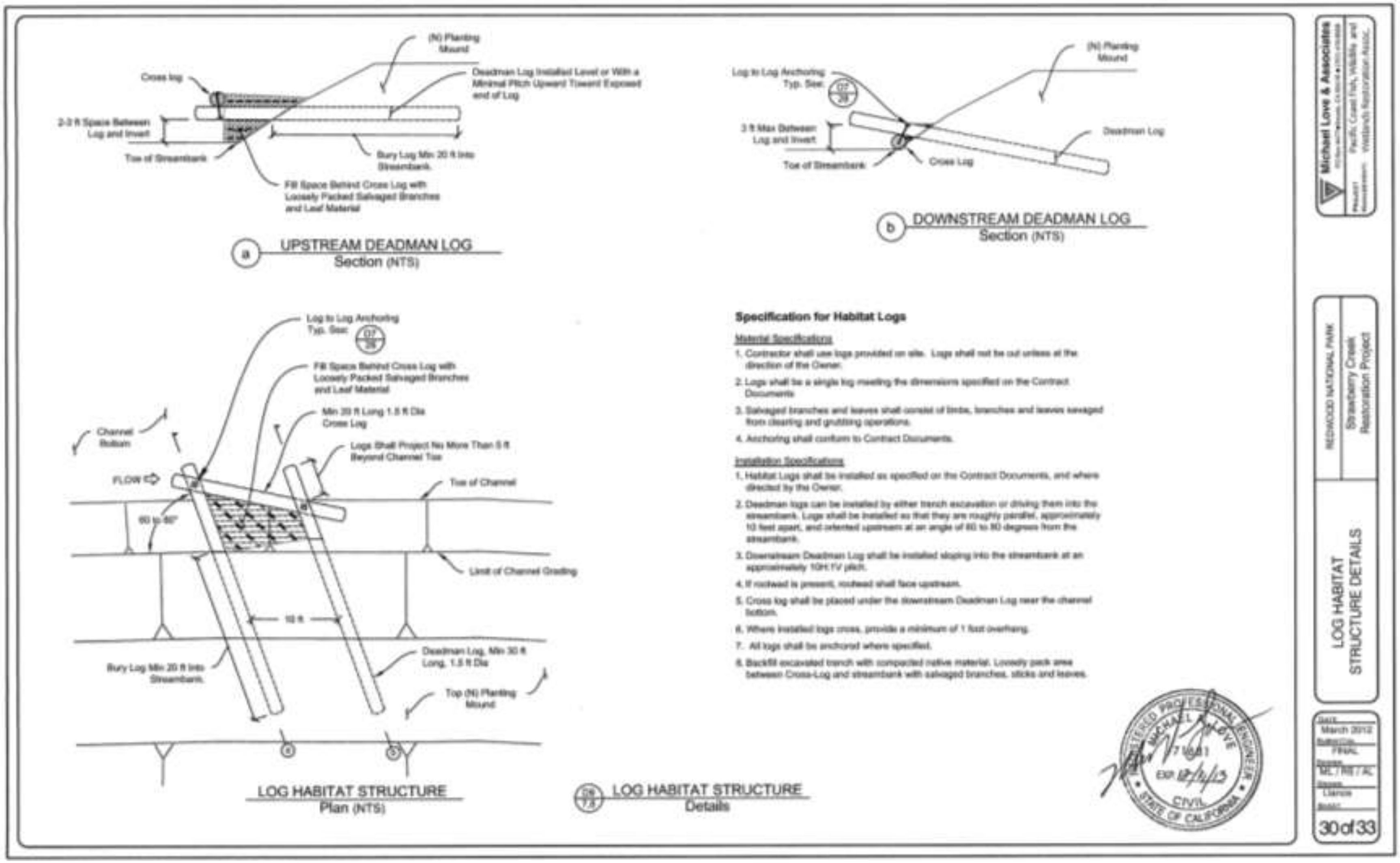


Figure A-14: Alternative 2 (proposed action)—log habitat structures (from Love and Shea 2012)

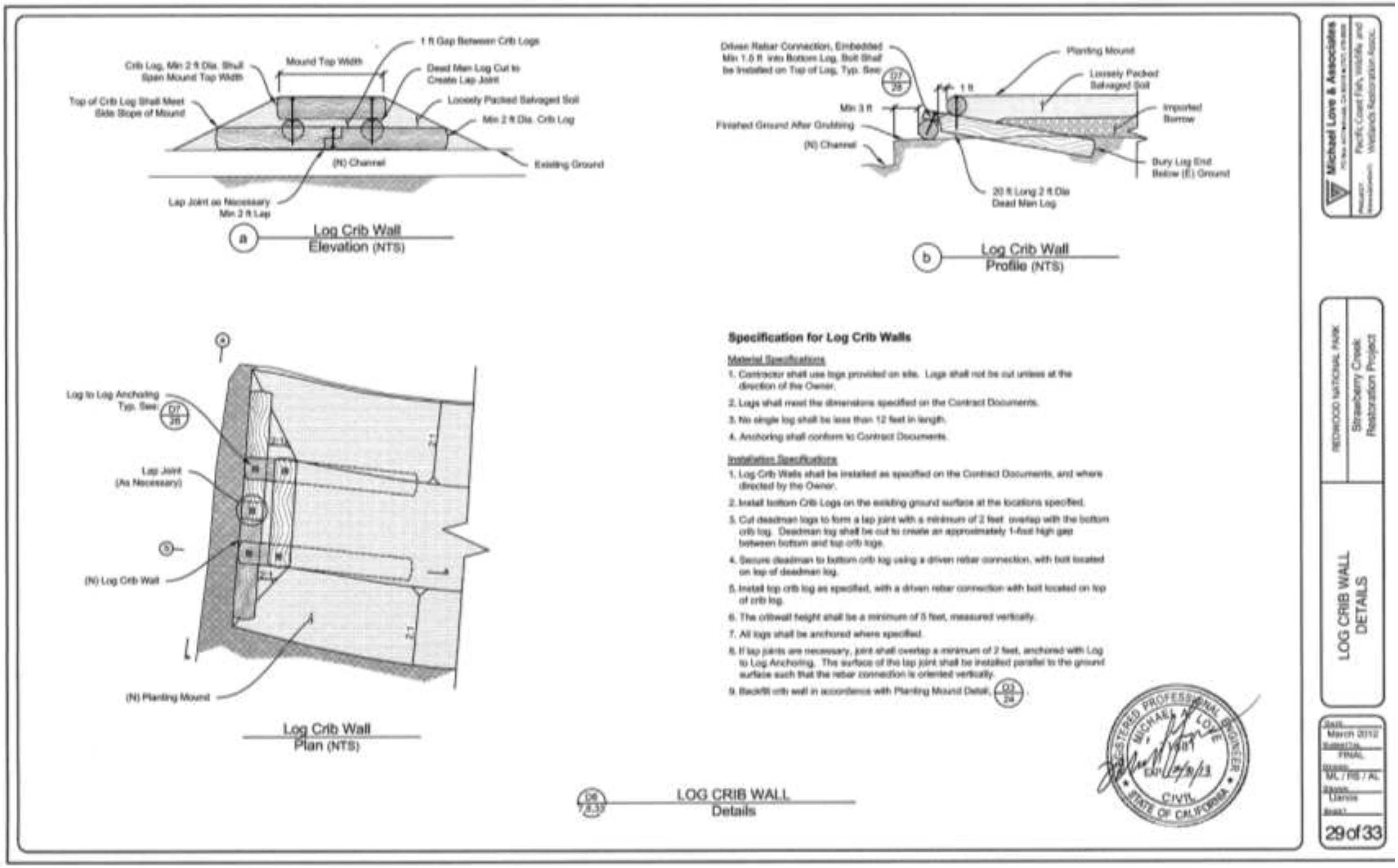


Figure A-15: Alternative 2 (proposed action)—crib wall (from Love and Shea 2012)

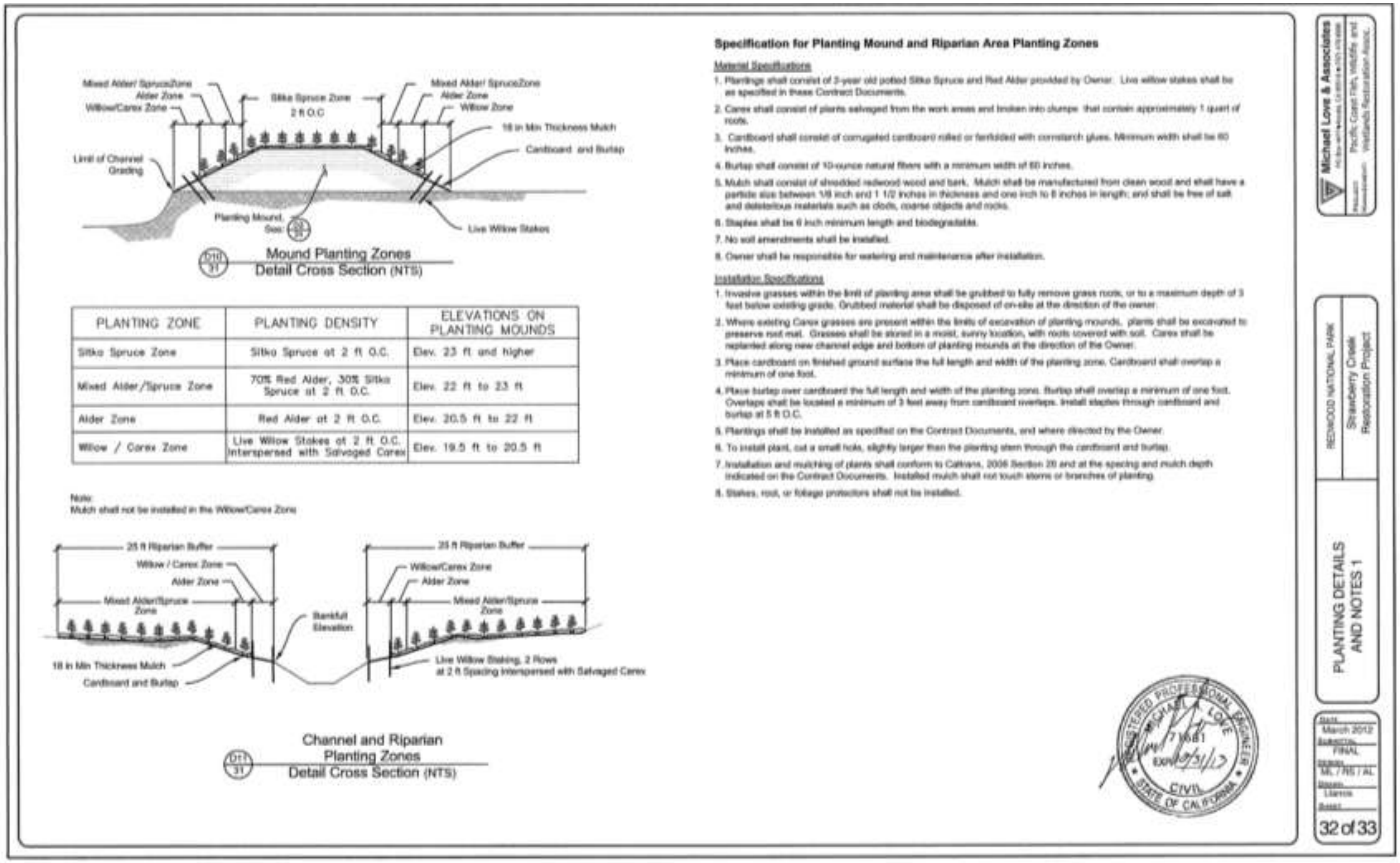


Figure A-16: Alternative 2 (proposed action) and Alternative 3—channel and riparian planting zones on mounds and on existing ground surface (from Love and Shea 2012)

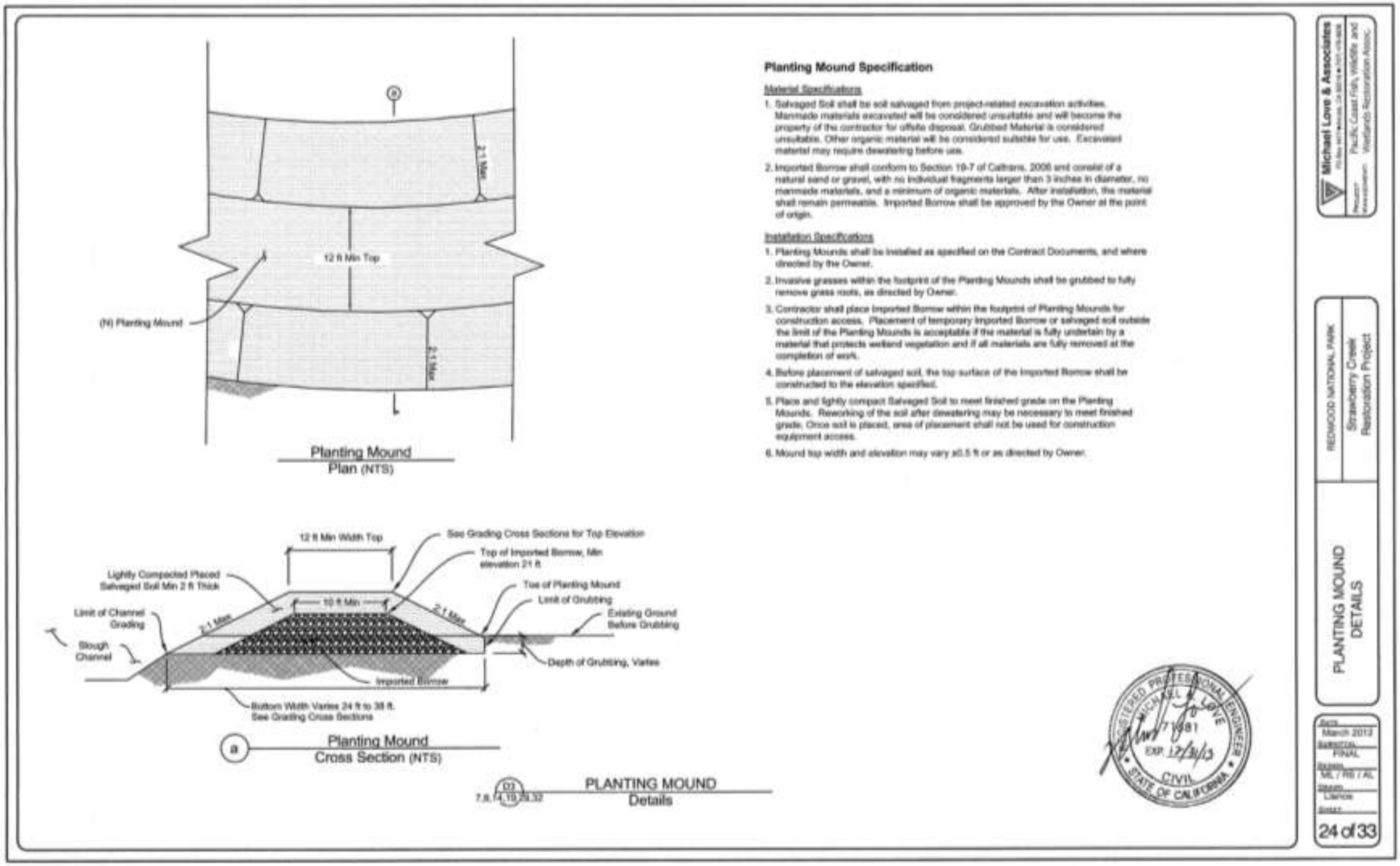


Figure A-17: Alternative 2 (proposed action)—planting mound specifications (from Love and Shea 2012)

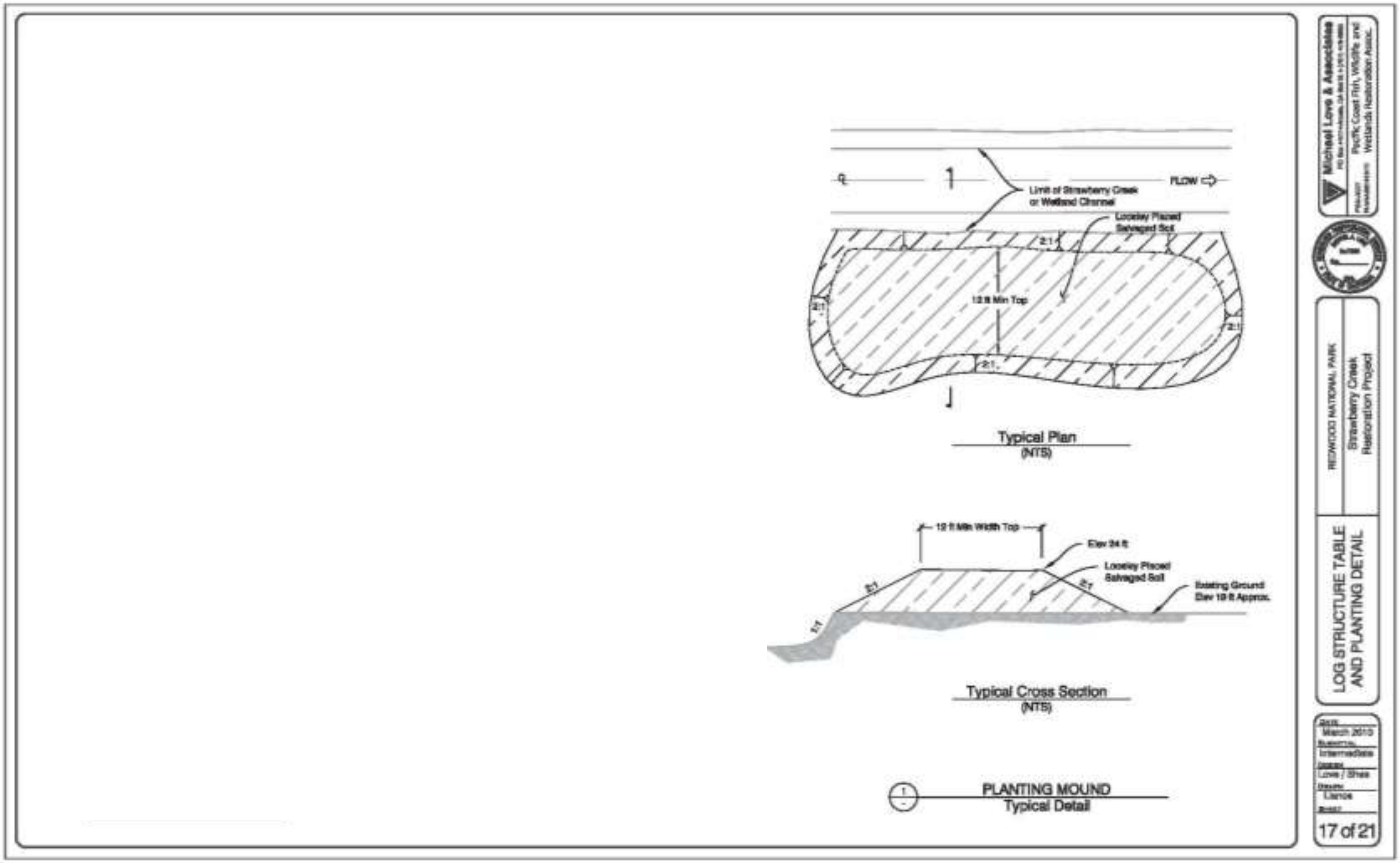


Figure A-18: Alternative 3-planting mound specification (adapted from Love and Shea 2010)

Appendix B: Wetland Functions and Values

Comparison of Wetland Functions and Values Before and After Restoration

Categories of wetland functions and values described here are found in the NPS *Procedural Manual #77-1: Wetland Protection*.

Proposed Restoration Element	Functions	before restoration action / after restoration action	Value before/after restoration (high/med/low/none)
Channel Restoration	**Biotic functions**		
Riverine Upper Perennial (stream channels) Palustrine Emergent (riparian plantings & mounds)	1. Fish habitat/ anadromous fish habitat [feeding, rearing, spawning]	Limited for non-anadromous; no anadromous habitat//	Low for non-anadromous; no anadromous habitat/moderate for non-anadromous/moderate for anadromous
		non-natal rearing habitat created for anadromous fish; culverts and instream structures allow fish passage for all anadromous life stages	
	2. Wildlife habitat	Marsh habitat for birds, amphibians, small mammals	Lower habitat diversity/higher due to addition of stream and riparian habitats
		Stream and riparian habitats added; increase potential for Pacific giant salamanders in stream channels and mink, otters, and beavers	
	3. Floral productivity	Marsh species	Lower/higher compared to existing due to addition of riparian habitats
		stream, riparian added to remaining marsh	
	4. Faunal productivity	marsh habitat	Moderate/Higher compared to existing due to addition of stream and riparian habitats
		marsh, stream and riparian habitats	
	5. Native species diversity	RCG dominates; native plants	Lower/moderate with addition of native plantings on mounds
		RCG removed from about 2.2 ac; native species planted	
	6. Habitat diversity	Palustrine Emergent	Low/Higher compared to existing due to addition of stream and riparian habitats
		Palustrine Emergent , and stream and riparian habitats added	
	7. Threatened and endangered species	Marsh not accessible to threatened anadromous salmonids; very low dissolved oxygen during summer flows/	No anadromous habitat (low)/Non-natal rearing habitat for coho salmon, accessible to steelhead (moderate)
		Stream habitat for anadromous salmonids (SONCC coho, NC steelhead)	

	Hydrologic functions		**Value**
	1) Flood attenuation	Marsh attenuates catastrophic flooding; lack of channel causes less-than-catastrophic flood flows to cover private pasturelands	floodwaters attenuated by marsh/ some floodwaters conveyed into South Slough, reducing flooding of private pastureland
		channel and culverts designed to convey flood flows in stream; remaining 30 ac marsh spreads flood flows over fields	
	2) Streamflow maintenance	No defined stream channel	Channel restoration and culvert sizing improve maintenance of year-round stream flow
		channel and culverts designed to convey flows within	
	3) Ground water recharge and discharge	No change after restoration because 30ac of marsh remain	Adjacent marshes continue to provide this function
	4) Water supply	No change after restoration because 30 ac of marsh remain	Adjacent marshes continue to provide this function
	5) Erosion and sediment control	Adjacent marshes capture overbank sediment deposition	Marsh traps sediment from upslope abandoned logging roads but aggrades channel/Channels designed to transport sediment to maintain clear channel; 4 stream crossings removed to prevent sedimentation of stream and aggradation
		grade-control structures designed with deposition and transport reaches; upslope stream crossing removal estimated 630 cu yd sediment prevented from deposition into restored channels	
	6) Water purification	Adjacent marshes continue to provide this function to capture sediment from erosion of abandoned logging roads upslope	Adjacent marshes continue to provide this function/ upslope stream crossing removal prevents 630 cu yd sediment from deposition into restored channels and marsh
		upslope stream crossing removal prevents estimated 630 cu yd sediment from deposition into creek and marsh	
	7) Detrital export to downstream systems	Marsh traps detritus with no export to downstream reaches	Low to none/moderate
		Riparian zone/mound plantings would increase input from trees; channel would convey hillslope and riparian detritus into downstream reaches	
	Cultural values	**Function**	**Value**
	1) Esthetics	No major visual intrusions into pastoral rural setting with tree-covered hillslopes	Moderate/higher after vegetation takes hold and some protective fencing is removed; riparian plantings visible from Orick & highway
		Stream channel with riparian zone generally considered appealing; initial adverse appearance from grading, planting, fencing	

	2) Education	No general interpretation for public; occasional park-sponsored field trips Opportunity for improved understanding of alterations to wetlands, effects of invasive plants, restoration of anadromous fishery	Low interpretive value of marsh/high after restoration from easy access to restoration area along SOC Road
	3) Historical values	no significant historic properties; former anadromous fishery is anecdotally considered locally significant	Low/historic fishery may be improved downstream of park
	4) Archeological values	No significant known values	No effect
	5) recreation	No general public access or park recreational opportunities; birding is dominant recreational activity increased production of steelhead, coastal cutthroat trout downstream would benefit sportfishing in Redwood Creek	Wildlife observation (birding) at marsh is primary recreational opportunity/Improved fishery [outside park] over long-term
	6) interpretation	No general interpretation for public; occasional park-sponsored field trips Opportunity for improved understanding of alterations to wetlands, effects of invasive plants, and restoration of anadromous fishery	Currently no general interpretive programs offered/High for park visitors as interpretive programs are developed about restoration project
	Economic Values	**Function**	**Value**
	1) Flood protection	Marsh attenuates general flooding but increases flooding on some private pasturelands Channel & culverts sized to convey flood flows to estuary	Moderate/Reduce flooding on some private lands
	2) fisheries	Historic coastal cutthroat trout fishery lost; no habitat for coho, steelhead Long-term improvement for steelhead, coastal cutthroat trout, and coho production	None/Moderate for Redwood Creek system with addition of rearing habitat
	3) tourism	Same as park recreational and interpretive values Opportunity for educational and interpretive programs and improved understanding of alterations to wetlands, and improvement of anadromous fishery regionally	Same as park recreational and interpretive values

Appendix C: Plant Species

List of Plant Species Observed at the former South Operation Center and Strawberry Creek project area

Family	Genus	species		Sub species	Common Name	I=introduced, N=native
SAPINDACEAE	*Acer*	*macrophyllum*			Big-Leaf Maple	N
ASTERACEAE	*Achillea*	*millefolium*			Common Yarrow, Milfoil	N
POACEAE	*Agrostis*	*gigantea*			Redtop, Bentgrass	I
POACEAE	*Agrostis*	*stolonifera*			Creeping Bentgrass	I
BETULACEAE	*Alnus*	*rubra*			Red Alder	N
MYRSINACEAE	*Anagallis*	*arvensis*			Scarlet Pimpernel	I
ASTERACEAE	*Anaphalis*	*margaritacea*			Pearly Everlasting	N
POACEAE	*Anthoxanthum*	*odoratum*			Sweet Vernal Grass	I
WOODSIACEAE	*Athyrium*	*filix-femina*	var	*cyclosorum*	Lady Fern	N
ASTERACEAE	*Baccharis*	*pilularis*			Coyote Brush, Chaparral Broom	N
ASTERACEAE	*Bellis*	*perennis*			English Daisy	I
BLECHNACEAE	*Blechnum*	*spicant*			Deer Fern	N
POACEAE	*Bromus*	*hordeaceus*			Soft Chess	I
BRASSICACEAE	*Capsella*	*bursa-pastoris*			Shepherds Purse	I
BRASSICACEAE	*Cardamine*	*californica*		*none*	Milkmaids, Toothwort	N
CYPERACEAE	*Carex*	*obnupta*			Slough Sedge	N
CARYOPHYLLACEAE	*Cerastium*	*arvense*	var	*strictum*	Field Chickweed	N
ONAGRACEAE	*Chamerion*	*angustifolium*	sub sp	*circumvagum*	Fireweed	N
ASTERACEAE	*Cirsium*	*arvense*			Canada Thistle	I
ASTERACEAE	*Cirsium*	*vulgare*			Bull Thistle	I
MONTIACEAE	*Claytonia*	*sibirica*			Candyflower	N
POACEAE	*Dactylis*	*glomerata*			Orchard Grass	I
APIACEAE	*Daucus*	*carota*			Wild Carrot, Queen Anne's Lace	I
PAPAVERACEAE	*Dicentra*	*formosa*			Bleeding Heart	N
PLANTAGINACEAE	*Digitalis*	*purpurea*			Foxglove	I
DRYOPTERIDACEAE	*Dryopteris*	*arguta*			Coastal Shield Fern	N
CYPERACEAE	*Eleocharis*	*macrostachya*			Common Spikerush	N
EQUISETACEAE	*Equisetum*	*arvense*			Common Horsetail	N
POACEAE	*Festuca*	*arundinacea*			Reed Fescue, Alta Fescue	I
POACEAE	*Festuca*	*perennis*			Italian Ryegrass	I
RHAMNACEAE	*Frangula*	*purshiana*			Cascara Sagrada	N
RUBIACEAE	*Galium*	*aparine*			Goosegrass	N

Family	**Genus**	**species**		**Sub species**	**Common Name**	**I=introduced, N=native**
ERICACEAE	*Gaultheria*	*shallon*			Salal	N
GERANIACEAE	*Geranium*	*dissectum*			Cutleaf Geranium	I
POACEAE	*Glyceria*	*fluitans*			Water Mannagrass	I
POACEAE	*Glyceria*	*occidentalis*			Western mannagrass	N
ARALIACEAE	*Hedera*	*helix*			English Ivy	I
POACEAE	*Holcus*	*lanatus*			Velvet Grass	I
ARALIACEAE	*Hydrocotyle*	*ranunculoides*			Marsh Pennywort	N
ASTERACEAE	*Hypochaeris*	*radicata*			Hairy Cat's Ear	I
AQUIFOLIACEAE	*Ilex*	*aquifolium*			English Holly	I
JUNCACEAE	*Juncus*	*bufonius*			Toad Rush	N
JUNCACEAE	*Juncus*	*effusus*	sub sp	*pacificus*	Pacific Rush	N
LEMNACEAE	*Lemna*				Duckweed	N
FABACEAE	*Lupinus*	*rivularis*			Riverbank Lupine	N
JUNCACEAE	*Luzula*	*comosa*			Woodrush	N
ARACEAE	*Lysichiton*	*americanum*			Yellow Skunk Cabbage	N
RUSCACEAE	*Maianthemum*	*dilatatum*			False Lily of the Valley	N
CUCURBITACEAE	*Marah*	*oreganus*			Wild Cucumber, Coast Manroot	N
ASTERACEAE	*Matricaria*	*discoidea*			Pineapple Weed, Rayless Chamomile	I
ERICACEAE	*Menziesia*	*ferruginea*			Mock Azalea, False Azalea	N
PHRYMACEAE	*Mimulus*	*guttatus*			Sticky Monkeyflower	N
APIACEAE	*Oenanthe*	*sarmentosa*			Water Parsley	N
OXALIDACEAE	*Oxalis*	*oregana*			Redwood Sorrel	N
ASTERACEAE	*Petasites*	*frigidus*	var	*palmatus*	Arctic Sweet Coltsfoot	N
POACEAE	*Phalaris*	*arundinacea*			Reed Canary Grass	N/I*
PINACEAE	*Picea*	*sitchensis*			Sitka Spruce	N
PLANTAGINACEAE	*Plantago*	*lanceolata*			English Plantain, Ribgrass	I
POACEAE	*Poa*	*pratensis*	sub sp	*pratensis*	Kentucky Bluegrass	N/I
POLYGONACEAE	*Polygonum*	*aviculare*	sub sp	*depressum*	Common Knotweed, Oval-leaf Knotweed	I
DRYOPTERIDACEAE	*Polystichum*	*munitum*			Western Sword Fern	N
ROSACEAE	*Potentilla*	*anserina*	sub sp	*pacifica*	Beach Silverweed	N
LILIACEAE	*Prosartes*	*smithii*			Smith's Fairy Bells	N
LAMIACEAE	*Prunella*	*vulgaris*	var	*vulgaris*	Common Selfheal	I
PINACEAE	*Pseudotsuga*	*menziesii*	var	*menziesii*	Douglas-fir	N
DENNSTAEDTIACEAE	*Pteridium*	*aquilinum*	var	*pubescens*	Bracken Fern	N
RANUNCULACEAE	*Ranunculus*	*repens*			Creeping Buttercup	I
BRASSICACEAE	*Raphanus*	*sativus*			Wild Radish	I

Family	Genus	species		Sub species	Common Name	I=introduced, N=native
GROSSULARIACEAE	*Ribes*	*sanguineum*	var	*glutinosum*	Red Flowering Currant	N
ROSACEAE	*Rubus*	*armeniacus*			Himalaya Blackberry	I
ROSACEAE	*Rubus*	*parviflorus*			Thimbleberry	N
ROSACEAE	*Rubus*	*spectabilis*			Salmonberry	N
ROSACEAE	*Rubus*	*ursinus*			California Blackberry	N
POLYGONACEAE	*Rumex*	*acetosella*			Sheep Sorrel	I
POLYGONACEAE	*Rumex*	*crispus*			Curly Dock	I
SALICACEAE	*Salix*	*hookeriana*			Coastal Willow	N
SALICACEAE	*Salix*	*lasiolepis*			Arroyo Willow	N
SALICACEAE	*Salix*	*scouleriana*			Scouler's Willow	N
SALICACEAE	*Salix*	*sitchensis*			Sitka Willow	N
ADOXACEAE	*Sambucus*	*racemosa*			Red Elderberry	N
CYPERACEAE	*Scirpus*	*microcarpus*			Panicled Bulrush	N
SCROPHULARIACEAE	*Scrophularia*	*californica*		none	Beeflower, California Figwort	N
ASTERACEAE	*Senecio*	*minimus*			Coastal Burnweed	I
CUPRESSACEAE	*Sequoia*	*sempervirens*			Coastal Redwood	N
BRASSICACEAE	*Sisymbrium*	*officinale*			Hedge Mustard	I
ASTERACEAE	*Sonchus*	*asper*	sub sp	*asper*	Prickly Sow Thistle	I
CARYOPHYLLACEAE	*Spergula*	*arvensis*	sub sp	*arvensis*	Spurrey, Stickwort, Starwort	I
LAMIACEAE	*Stachys*	*ajugoides*	var	*rigida*	Hedge Nettle	N
CARYOPHYLLACEAE	*Stellaria*	*media*			Common Chickweed	I
ASTERACEAE	*Taraxacum*	*officinale*			Dandelion	I
SAXIFRAGACEAE	*Tellima*	*grandiflora*			Fringe Cups	N
SAXIFRAGACEAE	*Tolmiea*	*diplomenziesii*			Pigaback Plant	N
MYRSINACEAE	*Trientalis*	*latifolia*			Starflower	N
FABACEAE	*Trifolium*	*repens*			White Clover	I
PINACEAE	*Tsuga*	*heterophylla*			Western Hemlock	N
TYPHACEAE	*Typha*	*latifolia*			Broad Leaved Cattail	N
URTICACEAE	*Urtica*	*dioica*	sub sp	*gracilis*	American Stinging Nettle	N
URTICACEAE	*Urtica*	*dioica*	sub sp	*holosericea*	Hoary or Stinging Nettle	N
ERICACEAE	*Vaccinium*	*ovatum*			Evergreen or California Huckleberry	N
ERICACEAE	*Vaccinium*	*parvifolium*			Red Huckleberry	N
BERBERIDACEAE	*Vancouveria*	*hexandra*			Inside-Out Flower	N
PLANTAGINACEAE	*Veronica*	*americana*			Speedwell, American Brooklime	N
FABACEAE	*Vicia*	*americana*	sub sp	*americana*	American Vetch	N
FABACEAE	*Vicia*	*sativa*	sub sp	*nigra*	Common Vetch, Garden Vetch	I

Family	Genus	species		Sub species	Common Name	I=introduced, N=native
VIOLACEAE	*Viola*	*sempervirens*			Redwood or Evergreen Violet	N

*=Native populations of reed canary grass that have not been exposed to gene flow form non-native strains may longer occur in North America. Additionally, morphological variability makes it difficult, if not impossible, to distinguish between native and non-native populations (Waggy 2010).

Appendix D: Bird List

This list includes birds detected along the SOC Road to intersection with Hiltons Road and upslope above the SOC Road. Species in **bold type** are on the list of *California Bird Species of Special Concern* (Shufard and Gardali, 2008).

[PLP = Private Lands Ephemeral Ponds]

1. Pied-billed Grebe (*Podilymbus podiceps*) [PLP]
2. Great Egret (*Ardea alba*)
3. Great Blue Heron (*A. herodias*)
4. Greater White-fronted Goose (*Anser albifrons*) [PLP]
5. Canada Goose (*Branta canadensis*) [PLP]
6. Wood Duck (*Aix sponsa*) [PLP]
7. Mallard (*Anas platyrhynchos*) [PLP]
8. Gadwall (*A. strepera*) [PLP]
9. Green-winged Teal (*A. crecca*) [PLP]
10. Cinnamon Teal (*A. cyanoptera*) [PLP]
11. American Wigeon (*A. americana*) [PLP]
12. Northern Pintail (*A. acuta*) [PLP]
13. Northern Shoveler (*A. clypeata*) [PLP]
14. Ring-necked Duck (*Aythya collaris*) [PLP]
15. Lesser Scaup (*A. affinis*) [PLP]
16. Bufflehead (*Bucephala albeola*) [PLP]
17. Common Merganser (*Mergus merganser*) [PLP]
18. Hooded Merganser (*Lophodytes cucullatus*) [PLP]
19. Turkey Vulture (*Cathartes aura*)
20. Osprey (*Pandion haliaetus*)
21. **Northern Harrier (*Circus cyaneus*)**
22. Bald Eagle (*Haliaeetus leucocephalus*)
23. Sharp-shinned Hawk (*Accipiter striatus*)
24. Red-shouldered Hawk (*Buteo lineatus*)
25. Red-tailed Hawk (*B. jamaicensis*)
26. American Kestrel (*Falco sparverius*)
27. Merlin (*F. columbarius*)
28. Peregrine Falcon (*F.peregrinus*)
29. Wild Turkey (*Meleagris gallopavo*)
30. California Quail (*Callipepla californica*)
31. Virginia Rail (*Rallus limicola*)
32. American Coot (*Fulica americana*) [PLP]
33. Killdeer (*Charadrius vociferus*)
34. Spotted Sandpiper (*Actitis macularius*)
35. Bonaparte’s Gull (*Chroicocephalus philadelphia*) [PLP]
36. Mew Gull (*Larus canus*) [PLP]
37. Marbled Murrelet (*Brachyramphus marmoratus*)

38. Band-tailed Pigeon (*Patagioenas fasciata*)
39. Northern Pygmy-Owl (*Glaucidium gnoma*)
40. Vaux's Swift (*Chaetura vauxi*)
41. Anna's Hummingbird (*Calypte anna*)
42. Rufous Hummingbird (*Selasphorus rufus*)
43. Allen's Hummingbird (*S. sasin*)
44. Belted Kingfisher (*Megaceryle alcyon*)
45. Northern Flicker (*Colaptes auratus*)
46. Red-breasted Sapsucker (*Sphyrapicus ruber*)
47. Downy Woodpecker (*Picoides pubescens*)
48. Hairy Woodpecker (*P. villosus*)
49. Pileated Woodpecker (*Dryocopus pileatus*)
50. Pacific-slope Flycatcher (*Empidonax difficilis*)
51. Black Phoebe (*Sayornis nigricans*)
52. Hutton's Vireo (*Vireo huttoni*)
53. Steller's Jay (*Cyanocitta stelleri*)
54. Gray Jay (*Perisoreus canadensis*)
55. American Crow (*Corvus brachyrhynchos*)
56. Common Raven (*C. corax*)
57. Tree Swallow (*Tachycineta bicolor*)
58. Violet-green Swallow (*T. thalassina*)
59. Cliff Swallow (*Petrochelidon pyrrhonota*)
60. Northern Rough-winged Swallow (*Stelgidopteryx serripennis*)
61. Barn Swallow (*Hirundo rustica*)
62. Wrentit (*Chamaea fasciata*)
63. Black-capped Chickadee (*Poecile atricapillus*)
64. Chestnut-backed Chickadee (*P. rufescens*)
65. Brown Creeper (*Certhia americana*)
66. Red-breasted Nuthatch (*Sitta canadensis*)
67. Pacific (formerly "Winter") Wren (*Troglodytes troglodytes*)
68. Marsh Wren (*Cistothorus palustris*)
69. Golden-crowned Kinglet (*Regulus satrapa*)
70. Ruby-crowned Kinglet (*R. calendula*)
71. Western Bluebird (*Sialia mexicana*)
72. Swainson's Thrush (*Catharus ustulatus*)
73. Hermit Thrush (*C.guttatus*)
74. Varied Thrush (*Ixoreus naevius*)
75. American Robin (*Turdus migratorius*)
76. European Starling (*Sturnus vulgaris*)
77. American Pipit (*Anthus rubescens*)
78. Cedar Waxwing (*Bombycilla cedrorum*)
79. Orange-crowned Warbler (*Oreothlypis celata*)
80. Yellow-rumped Warbler (*Dendroica coronata*)
81. Townsend's Warbler (*D. townsendi*)
82. Yellow Warbler (*D. petechia*)
83. Wilson's Warbler (*Wilsonia pusilla*)

84. Common Yellowthroat (*Geothlypis trichas*)
85. Spotted Towhee (*Pipilio maculatus*)
86. Fox Sparrow (*Passerella iliaca*)
87. Lincoln's Sparrow (*Melospiza lincolnii*)
88. Song Sparrow (*M. melodia*)
89. Swamp Sparrow (*M. georgiana*)
90. White-crowned Sparrow (*Zonotrichia leucophrys*)
91. Golden-crowned Sparrow (*Z. atricapilla*)
92. Dark-eyed Junco (*Junco hyemalis*)
93. Black-headed Grosbeak (*Pheucticus melanocephalus*)
94. Red-winged Blackbird (*Agelaius phoeniceus*)
95. Brewer's Blackbird (*Euphagus cyanocephalus*)
96. Brown-headed Cowbird (*Molothrus ater*)
97. Purple Finch (*Carpodacus purpureus*)
98. Pine Siskin (*Spinus pinus*)
99. American Goldfinch (*S. tristis*)
100. Red Crossbill (*Loxia curvirostra*)